

Metallurgical *and* Chemical Engineering

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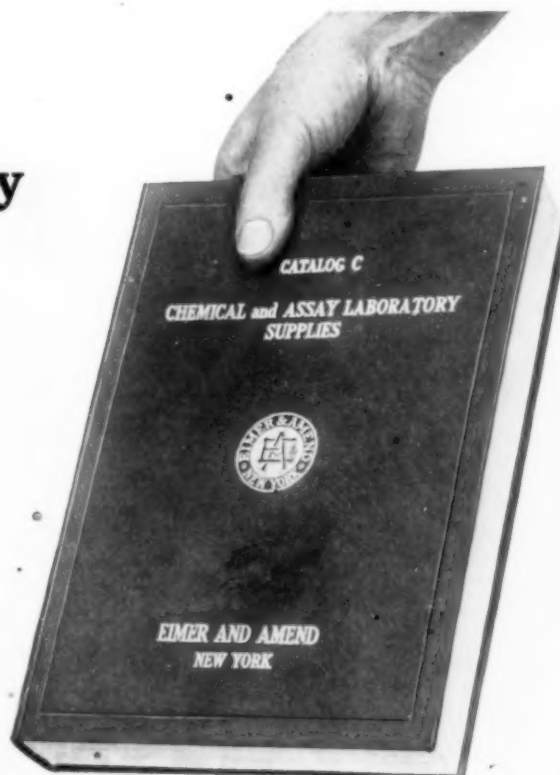
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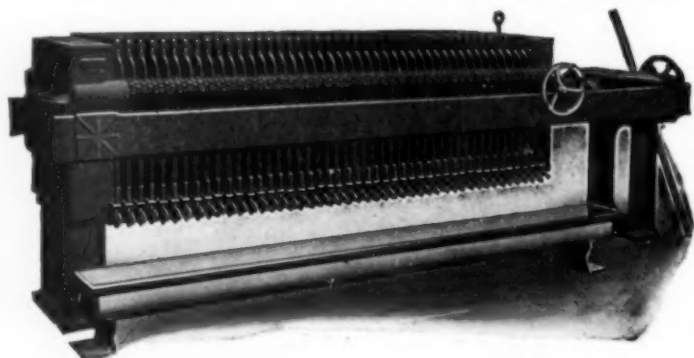
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METALLURGICAL & CHEMICAL ENGINEERING

ISSUE OF AUGUST, 1913

Cyanide Practice in the Black Hills, South Dakota. By H. C. Parmelee..... 435

A second illustrated article on modern cyanide practice in the Black Hills of South Dakota with special reference to the Bismarck mine and the new Reliance mill. The feature of recent improvements in the latter has been the adoption of the continuous decantation system of slime treatment in Dorr thickeners, followed by vacuum filtration in a Portland rotary filter.

The Ostwald Process for Making Nitric Acid from Ammonia..... 438

An illustrated article on the proposed combination of making nitric acid from ammonia with the manufacture of calcium cyanamide in an English plant. The cyanamide is to be employed to yield the ammonia needed as raw material for the manufacture of nitric acid by the Ostwald process. An illustrated description of the Ostwald process is given for making nitric acid from crude ammonia liquor.

Efficiency in Chemical Industries. By T. B. Wagner 443

His presidential address before the American Institute of Chemical Engineers in which he illustrates the principles of efficiency in chemical industries by a sketch of the development of the industry of corn products.

The Temperature of Certain Operations in the Metallurgy of Copper and Lead. By C. H. Clevenger 447

An account of careful measurements of certain important temperatures in metallurgical reactions. Figures are given for copper blast furnaces, copper reverberatory furnaces, copper refining furnaces, copper converters, lead blast furnaces, and several roasting furnaces.

Evolution of Methods of Handling Slime. By H. N. Spicer..... 451

A continuation of his profusely illustrated serial. In the present installment the author continues the discussion of practice on the Rand in South Africa and describes in greater detail some of the special methods that have been developed or introduced there from time to time and considers the practice at some of the individual mills.

Recovery of By-Products in the Modern By-Product Coke Oven. By C. A. Meissner..... 454

The section of his recent American Iron and Steel Institute paper, dealing with the recovery of by-products. The author discusses the nitric process for the recovery of ammonia, the Koppers semi-direct sulphate process, the Otto direct sulphate process, the Collin semi-direct sulphate process, the Feld direct sulphate process, the recovery of benzol, and the uses of the various by-products.

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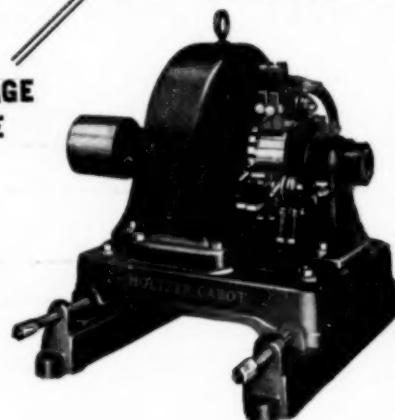
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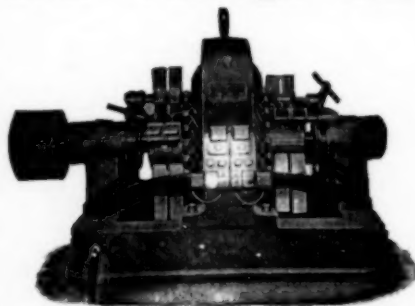
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Denver Meeting of the American Electrochemical Society

In this issue we publish the preliminary program of the meeting of the American Electrochemical Society, to be held in Denver, Boulder, and Golden, from Sept. 9 to 11, with two additional days in Colorado Springs, on Pike's Peak, and in Cripple Creek. It promises to be a charming and thoroughly enjoyable affair and the old and ever-young Electrochemical Society spirit which has distinguished so many brilliant former meetings will have an opportunity to manifest itself under new and particularly attractive and congenial conditions. To the Easterner it is an ever new revelation to enjoy the sublime grandeur of Colorado's natural beauties and the big-hearted Western hospitality, while the special train which is being arranged, if possible, right from New York, should be an additional inducement to insure a large representative attendance from the East.

But, then, there are deeper dormant potentialities in this convention. It will be the first Western meeting of the American Electrochemical Society. It will be the first official professional getting-together of Western metallurgists—proven pioneers and empire builders—and of Eastern electrochemists—again proven pioneers with a vision of extending their influence westward. But it will not be a raid into the enemy's country nor a clashing of commercial interests. Whatever electrochemistry can do for Western metallurgy will be welcomed and accepted there with the true spirit of Western hospitality.

It may be expected that there will be a good program of instructive papers on the relation of electrochemistry to metallurgy. But however instructive and interesting the papers will be, they alone will not exhaust the possibilities of the Denver meeting. It is in the direct personal contact between man and man in open discussion in the professional sessions and in quiet heart-to-heart talk that the most good can be accomplished. The Denver meeting should give ample opportunities in this direction and the sphere of subjects of mutual interest for discussion is wide. There is electric smelting, electrolytic processes as an adjunct to leaching, electromagnetic and electrostatic separation, electroamalgamation and electrocyanidation, and an almost unlimited number of special possibilities.

Taking everything together, the Denver meeting promises to become not only a truly charming affair, but a new milestone in the career of the Society and in the forward march of electrochemistry.

Investigating the Smelter Trust

Representatives of the federal Department of Justice are in the West studying the relation between the mining and smelting industries and investigating alleged unfair treatment of the miner by the smelter. The investigation, we understand, is of a general nature, but more particularly

with reference to the operations of the American Smelting & Refining Company, commonly known in Colorado and the West as the "smelter trust." If an investigation is needed, the government is late by several years in seeking the reasons for the unfeigned hatred and unconcealed distrust of the miner for the smelter; but at that it is ahead of the several western states which have agitated the question for years without accomplishing anything.

The government will find that the miner believes he does not get a square deal from the smelter, and the reasons assigned will be many and various. Much of the information volunteered will be non-essential, incompetent and immaterial, coming from miners who have long harbored a prejudice against the smelter, but who, in the last analysis, will be found lacking in a knowledge of the essential requirements of smelting and in ability to drive a fair bargain with the smelter, or to prepare and grade their ore so as to get the greatest net return. In this respect it will be necessary for the investigators to exercise good judgment as to the reliability and competence of their sources of information, and to discount mere grumbling dissatisfaction and deep-seated, ignorant prejudice.

It is highly improbable that any serious fault will be found with the methods of weighing, sampling, and arriving at the gross value of the ore. The miner has every legitimate opportunity to watch the sampling of the ore, either personally or through an agent; and he has a similar privilege in assaying his sample to determine the metallic content of his shipment. Neither is it conceivable that any reflection can be cast on the integrity of the assayers selected as umpires, nor any suspicion entertained that the smelter has ever used unfair means or exerted pressure to influence the umpires' results. In fact, it is difficult to see where any fault could be found along these lines.

The crux of the whole matter lies in smelting contracts and the basis on which final settlement is made, and the government, if it has a legitimate business to do so, may well direct its main efforts to ascertain whether these contracts are fair, equitable, impartial and clear, or the reverse; and whether the prices, penalties, bonuses, charges and other rates are justifiable. It is a fact that smelter contracts are needlessly cluttered with vague and involved terms. Direct, plain statement is a lost art in these documents. The miner is easily befuddled in trying to comprehend them, and frequently does not find the jokers until too late to eliminate them.

In fact, we have the principal psychological elements of a horse trade if we reverse the position of buyer and seller in the analogy. The novice buying a horse from a typical, shrewd trader, and the plain miner selling ore to the smelter, occupy similar positions of uncertainty, distrust, and inability to cope with the superior knowledge of the other party to the transaction. The average smelting contract is a mystic maze in which many a miner finds it difficult to find his way. Nor does it contribute to his composure to find that a neighboring miner may have a different contract on similar ore with the same company, and which is equally unintelligible to him.

The extent to which the smelter may control the market for the metals, particularly lead, is another point that may occupy the attention. The ability to make arbitrary prices,

for reasons best known to the smelter, may possibly work a hardship on the miner, and certainly adds to his feeling of dissatisfaction and distrust.

The investigation probably will require several months, and its result will be awaited with interest. It is by no means a foregone conclusion that the government will be able to establish a case against the smelter, nor is the inquiry being conducted with prejudice or bias. In the end it may be, and probably will be, without great profit, but it should shed some light on a subject which has agitated the Western mining industry for several years.

Flue-Dust Explosions at Smelting Plants

The occurrence of two disasters by explosion and fire at Utah lead smelting plants has directed attention to a contingency which apparently did not exist prior to the use of the latest method of sintering fine ore. At the Tooele smelter of the International Smelting & Refining Company an explosion of flue dust caused serious damage to the roaster flue, and at the Midvale plant of the United States Smelting Company a spontaneous fire destroyed a large number of bags. Both disasters involved material loss and were quite extraordinary. In the case of the flue-dust explosion the usual provision of explosion-doors was insufficient to prevent wrecking the flue, while the destruction in the bag-house fire was of much greater magnitude than that caused by incipient fires which sometimes occur in such plants.

In each case the trouble is ascribed to the presence of finely divided elemental sulphur in the gases from the sinter-roasters. This material, settling in the flue-dust and bag accretions, apparently gives rise to dust explosions when the conditions of temperature and oxidation are favorable, similar to the progressive explosions of other finely divided combustibles, such as coal dust. That similar explosions have not occurred before probably is due to the fact that in earlier forms of roasters the sulphur was eliminated as some form of oxide instead of a sublimed element, the latter apparently resulting from the present method of roasting. Both the plants mentioned employ the Dwight & Lloyd method of sinter-roasting, a characteristic feature of which is that a comparatively thin layer of ore is quickly agglomerated into a porous mass, highly suitable for smelting. The mixture is exposed to heat for only a short time, and the quantity of air available for oxidation is limited to that which can be drawn through the charge during its passage over the wind-boxes.

Under such conditions it is likely that more sulphur would be sublimed, and less oxidized, than in the old forms of hearth roasting furnaces, or in other forms of agglomerating furnaces. Thus, in the Huntington-Heberlein pot system of sinter-roasting, the charge is deeper, the air supply more copious, and the progressive sintering slower than in the Dwight & Lloyd method. There is a greater probability of sulphur being eliminated as oxide. It appears, however, that even with the Dwight & Lloyd system the tendency to distill sulphur into the flue gases varies with the physical condition of the roaster charge; and the likelihood of resulting explosions also is modified by these conditions. It has been observed that a very wet charge results

in the distillation of more sulphur than comes from a reasonably dry mixture. Some moisture is desirable in the mixture, in order to handle it properly, and indeed it is customary to add some water at times; but such excessive moisture as occurs in frozen ore apparently is detrimental.

The problem is being investigated, and probably will be well in hand before other disasters can occur. The suggestion has been made that the tendency to distill sulphur might be turned to advantage by creating conditions most favorable for this action, and recovering the sulphur thus formed. This would have a distinct bearing on the smelter fume question. At present, means are being adopted to cool the gases in the flues and further to regulate automatically the temperature of the gases entering the bag house by admitting a variable quantity of air with them.

Stimulus to By-Product Coking

What amounts to an artificial stimulus to the by-product coke industry is furnished by the Connellsville coke industry, in demanding prices for its beehive coke, which include large allowances for interest and exhaustion, based upon high valuations for Connellsville coal acreage. For several months the Connellsville operators have been engaged in an effort to secure \$2.50 for coke for delivery in the second half of this year, at a time when the price of pig iron would indicate a much lower price for coke, based upon the relations between pig iron and coke prices which have obtained in the past. The operators represent that the average price of coke has not furnished them a proper return upon the value of their properties. Whether the transactions were justified or not, Connellsville coal acreages have sold as high as \$1500 to \$2000 per acre, and on a 20-year life for the operation, at \$1500 an acre for the coal and an allowance for the investment in development, the interest, exhaustion and amortization charges amount to more than 50 cents per ton of coke produced, if full production is realized throughout the period. Average coke prices in the past few years have not carried such a margin beyond the bare factory cost, and the fact has been brought home with particular force to some operators, who bonded their properties on the basis of the cost of the coal acreage. Acreage values once assumed, the computation of cost of carrying the investment is simple, as the seam produces quite uniformly about 7000 tons of coke per acre.

The high values set upon Connellsville coal were based upon the theory that from no other coal could be produced a coke nearly as satisfactory for iron smelting as Connellsville. Within limitations, this assumption has been proved fairly correct, having regard only to the beehive process, but the introduction of the by-product process has entirely changed the situation.

The point is not that, *per se*, the by-product oven will produce as good coke as the beehive oven, with a considerably inferior coal. There are other important elements, growing out of the fact that the beehive oven is located at the pit mouth, while the by-product oven is located at the point of consumption. This difference gives rise to certain important factors. In the first place, the beehive coke must be shipped and the handling requires it to be of stronger and larger structure than the by-product. In the

second place, the beehive oven must be located upon a coal acreage certain to afford a satisfactory coal for a period of years; no chances can be taken. The by-product oven, on the other hand, can draw coal from anywhere, within the limits of freight cost. It can mix various coals and can change the mixture as often as desired. The owners can pick up small or large coal tracts in this place or that place as the market affords them favorable opportunity. Coal freights per ton average sufficiently less than coke freights to make the coal freight the less, per unit of coke, despite the larger tonnage moved. In the third place blast furnace designs can be modified so as to use with economy a coke of softer structure than the best of the Connellsville beehive coke. These considerations are not always taken into account, in addition to the well-known advantages of the by-product process, in its larger coke yield, and its yield of gas and other by-products.

As soon as high values for Connellsville coal acreage appeared, steel manufacturers recognized that the fact largely wiped out the disadvantage of the much greater capital investment involved in by-product oven construction as compared with beehive, for the beehive oven cannot be built unless an attendant supply of coal has been secured, while with the by-product plant this protection is less necessary, but in any event an equal coal acreage would cost much less money.

The placing of high values upon Connellsville coke thus stimulates the construction of by-product ovens. From what has occurred, taken in conjunction with current conditions and trends, the future can be forecasted with considerable accuracy. In 1900 the proportion of by-product to total coke made was 5 per cent; in 1905, 11 per cent; in 1912, 25 per cent, and in 1914, through the erection of plants now completed or in course of erection the proportion will not be far from 35 per cent. The growth in by-product coke production has been greater than the growth in total coke consumption, whereby it was as far back as in 1907 that the maximum production of beehive coke was reached, the 1912 production showing a decline of more than 6 per cent from this tonnage. In 1880 the Connellsville region produced 66 per cent of the total coke made in the United States. In 1890 the proportion had fallen to 56 per cent, chiefly through the rapid development in Alabama, but on account of the advantages of Lake Superior ore such outlying districts as Alabama and Tennessee did not keep up with the growth in pig iron production, and Connellsville coke maintained its proportion of about 55 per cent of the total through 1906. Then occurred a drop to about 45 per cent., which has been the average from 1907 to 1912, inclusive. This drop has been due chiefly to the growth of by-product coking. The production of Connellsville coke has been practically stationary, amounting in 1906 and in 1912 to 20,000,000 tons. At this rate, which certainly will not increase, the Connellsville region proper will be exhausted in about 20 years. The probability is strong that the remaining Connellsville coal will not all be made into coke in the region, but that shipments of Connellsville coal to by-product ovens, which have already commenced, will increase year by year. Few new beehive ovens will be built, as their life would be short, and old ovens will be abandoned, the remaining coal being shipped.

Readers' Views and Comments

Smelting Zinc in an Electric Furnace

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In a paper by Mr. Francis Louvrier, published in this magazine, November, 1912, on "Causes of the Practical Non-Success of Electric Furnaces in Treating Zinc Ores," he ascribes lack of success to the amount of blue powder produced in them, and attributes its formation to the oxidation of the reduced zinc by carbonic acid. He does not assume a greater production of carbonic acid than in ordinary practice, but believes that its more injurious effect is due to the rapidity with which it escapes from contact with hot carbon, which in part is due to the very rapid reduction of the zinc, and in part to a defect in the position of the electrodes.

It is not my purpose to review this article, or to discuss all of the questions raised. I believe the same object is often obtained in an argument by presenting a different point of view, as by proving that the other man was deceived by appearances. I shall suggest that the production of an excess of blue powder may not be due to an excess of oxidation; that even if it is, the carbonic acid formed by reduction may not be the oxidizing agent; that a more easily remedied defect than the position of the electrodes may be responsible for the rapid cooling of the zinc. I shall raise questions I do not expect to answer, but possibly others may supply, from their own experience, facts which will make explanation easier.

Some thirty-five years ago, I announced that a product closely resembling blue powder could be produced from distilled zinc, by methods of cooling, in no way oxidizing in their effect. I believe this is now generally accepted to be a fact. But the oxidation of some of the zinc in standard and proposed zinc furnaces is almost universally stated in current publications to be the reason why they produce blue powder. The intentional production of a large percentage of blue powder in the de Saulles furnace, for use in the arts, has some bearing on this question. I went even further at the time, and convinced myself by repeated experiment that the oxidation on a sample of ordinary blue powder produced in regular practice, which had been kept several months in my laboratory, was not sufficient to prevent the coalescence of its separate particles into a single liquid mass, under proper conditions of heat, without the application of pressure while heated, and without consolidation by compression before heating. The experiment was a very simple one, made in a Berzelius arsenic tube heated in a Bunsen flame. The powder melted readily, and had a brilliant lustre when in contact with the glass. It readily oxidized on top and was pitted with particles of oxide cinder and ore.

It may be admitted that any oxidation of the zinc has a retarding effect on its uniting as a single liquid mass, but I believe that it cannot be contended either that it is the sole or even the principal cause of the production of blue powder.

On the other hand, the fact should not be lost sight of that there are occurrences of zinc oxide in the products of every zinc furnace, other than the superficial coating on blue powder. A zinc smelter is not likely to confuse them even in thought. The skimmings of the ladles and the molds, and the scrapings from the condensers and the mouths of the retorts, contain zinc oxide which is regularly returned for a subsequent treatment. The passing in and out of the tool, in the drawing of the metal, introduces much air into the condensers; and when prolongs are not on the condensers, unless the workman is careful to keep the openings of the condensers nearly closed much air is drawn in when the temperature of the condenser falls, as it must under conditions of firing. Every smelter knows, and every user of blue powder must learn, that what goes by this name is far from uniform in composition. It

ranges, in the percentage of zinc which is present in the metallic state, from over 90 per cent. to less than 80 per cent., and it deteriorates rapidly by oxidation. It is to be regretted that more analyses have not been published, giving precise details, of the ores from which it was produced, of the manner in which it was collected, and of the conditions under which it was stored, and that this knowledge is not more accessible and widely diffused. Until this is done by some competent authority, it is necessary to insist on the great differences which are found between different samples of this product, and on the importance of distinguishing between them.

I cannot reach any conclusion as to what products Mr. Louvrier had in mind, when he ascribed the lack of success of electric zinc smelting, to their production.

If the phrase "excessive oxidation" is substituted for "production of blue powder" in his explanation, and this has been proved, and is not merely assumed from the formation of blue powder, then the source of this oxygen may profitably be looked for. I will say in passing, that it is improbable that a molecule of CO_2 can come in contact with carbon at the temperature of zinc reduction and escape being reduced to CO . These reactions are indeed successive, for CO_2 cannot react until it is formed. The time required for this molecular reaction occurring over a wide range of temperature must be very brief. It will be more profitable to look first into the two questions of temperature and contact, before recurring to this question of required time.

Two ideas thrown out by Mr. Louvrier in other connections afford valuable suggestions. The very rapid reduction (and distillation) of zinc, by the reaction $\text{ZnO} + \text{CO} = \text{Zn} + \text{CO}_2$, which is strongly endothermic, may exhaust the high-temperature heat and lower the temperature of the products, to such an extent that there is not enough high-temperature heat left to bring the surrounding carbon, gradually approaching the hottest zone, up to the temperature at which it will react promptly with CO_2 to reduce it. On the other hand, preponderance of evidence leads us to believe that CO must be present in considerable amount to reduce ZnO in the presence of CO_2 . If this be true there must be a very considerable reduction of CO_2 in the hottest zone of an electric furnace, and also in any cooler zone, where zinc is still reduced. This effect of rapidity of reaction is otherwise improbable, for the amount of CO_2 produced by reduction is directly proportional to the zinc reduced, and the more rapidly it is evolved, the less will be the amount of heat dissipated and lost. If reduction is effected by carbon, only CO would be formed, and there would be no CO_2 to be reduced. The effect of driving a furnace rapidly is to diminish the amount of heat lost by radiation, etc., other things being equal.

His other suggestion is, that the vertical position of one of the electrodes, which requires a certain free space, however slight, to move in, affords a line of least resistance for the escape of the evolved gases. The greater activity of reduction at the point of greatest heat, namely, at the end of the electrode, causes the charge to settle more rapidly above this point, and in this way diminishes the depth of the charge through which the gases must rise in order to emerge.

It is difficult to imagine an arrangement of electrodes which would secure a greater uniformity in the depth of the charge; but the idea advanced suggests the formation, within a uniformly filled furnace, of gas-filled cavities, due to greater chemical activity at these points. If the charge in the furnace is softened under the influence of heat, even to a very slight degree, these cavities would not be immediately filled by solid material dropping into them. The connection of such cavities would establish open passage ways throughout the charge, for the escape of gases, and their contact with hot carbon would

be reduced to a minimum. Thus the effect of an insufficient time exposure would be reached by poor conditions of contact.

With a charge consisting of ore mixed with carbon, which becomes more fusible as the carbon is removed by gasification, it is difficult to see how the formation of such cavities can be avoided, with the resulting irregular escape of the gases. I do not understand why experimenters in electric zinc smelting do not simplify their sufficiently difficult problem by experimenting with sublimed zinc oxide, which is practically infusible.

Although Mr. Louvri r appears to criticise all forms of electric furnaces, his specific references are to those of the arc type. To bring together my own criticisms of the data furnished, I will say in conclusion, that I think he overestimates the effect of oxidation. If indeed it occurs, and has the effect attributed to it, the source of the oxygen will probably be found to be air admitted around the electrodes, at the very point where it will do the most harm. In fact, it is very difficult to maintain electrodes passing through furnace walls, without allowing some air to pass in around them.

I think he has misjudged the effect of more rapid distillation, which should be to diminish, relatively, the loss of heat by radiation, etc., and consequently facilitate condensation of the zinc within the range of temperature through which this is possible. I think he has overlooked the time required to allow the liquid globules to come together after they are formed, and I think by fixing his attention on the time element in the reduction of CO_2 , to the exclusion of the elements of temperature and intimate contact, he has not noticed that the same effect may be produced in very much less time, under more favorable circumstances. Apparently he has not considered the effect of the local softening of the charge under the heat conditions of an electric furnace, in facilitating the irregular passage of the gases through it, and on the rapid cooling of the gaseous products.

But in spite of these somewhat minute criticisms, his paper gives evidence of good thinking, and of a desire to weigh carefully such information as has been given out by experimenters with electric furnaces. A great advance in general knowledge would result if more articles like his were written and published.

F. L. CLERC.

Estes Park, Colorado.

The Pinch Effect and the Pinch-Effect Electric Furnace

To the Editor of Metallurgical and Chemical Engineering:

Sir: On a short recent visit to this country, Dr. Carl Hering, the well-known author on the "Pinch Phenomenon," read a short lecture on this subject and demonstrated a small model of his furnace, designed on the pinch-effect principle. The lecture was held before a special gathering of the Faraday Society in the Northampton Institute in London and was evidently much appreciated by the members present. In his clear, lucid manner, Dr. Hering gave a brief but instructive r sum  of his researches and the furnace as an outcome thereof.

The model itself was, owing to the fact that it must be as portable as possible, of the simplest nature, only intended for short demonstrations with lead as a charge; but the underlying principle of Dr. Hering's invention could be easily studied by means of it, and it seemed to work perfectly well under the prevailing conditions.

As a special feature, Dr. Hering drew our attention to the effect of two auxiliary channels emanating from the main electrodes, converging toward the center of the bath. It could be clearly seen how, contrary to expectations, the metal was readily sucked into these latter channels, while it was constantly ejected on the periphery of the main channels. Dr. Hering said that he reserved his comments regarding this point for the future; it was evident, however, that this added most effectively to the circulation of the bath.

Various designs were shown on slides and drawings, demonstrating different methods of application of the main principle.

On the whole, the furnace appeared to be very effective

along the lines demonstrated; it would, of course, be difficult to judge how it would behave as a commercial tool when used on liquid steel on a large scale and for a prolonged run.

One difficulty seems to be in the starting up from cold; but where liquid metal is obtainable for the start this seems to be of minor importance. Another is the application of two or more openings or channels near the bottom; every steel man is by nature somewhat shy of any holes or recesses in the bottom of his furnace, when he has a charge of several tons of expensive steel, superheated and highly liquid, on the hearth. But Dr. Hering assured that there was little danger in breaking through. No figures regarding the power consumption per ton of treated metal were given, but it was understood that some larger furnaces were under preparation with which such figures would be obtained.

During the course of the lecture, Dr. Hering stated that steel had been refined down to 0.006 per cent of sulphur. The amount of sulphur in the metal charged was not stated, but this is of less importance. Of far more importance, however, is the question how such far going desulphurization is effected in a furnace, where the slag blanket is heated secondarily by means of the underlying metal. This question was raised in the discussion; Dr. Hering attributed it to be caused through the "washing" action of the highly agitated metal. But even so, the result would be remarkable.

As well known, it is easy enough to lower the percentage of sulphur down to, say, 0.02 or 0.03 per cent, but to bring it down to 0.006 is considerably more difficult. As already pointed out by the author some four years ago, and since often enough corroborated in technical journals, one has a good indicator of a thorough desulphurization when calcium carbide is found to form in the slag; i.e., when the slag itself has been hot enough to show distinct traces of carbide, one may be fairly sure that the possibilities for the sulphur to enter into the slag as calcium sulphide were present.

Now that a rapid agitation of the steel-bath will facilitate the contact between the sulphur in the metal and the superheated slag is quite clear; another question is, however, how far would it be possible to drive the elimination of the sulphur when the slag is heated indirectly from the superheated metal bath, and what would be the metallurgical explanation of the reaction? This question might lend itself to discussion, since the mere statement that such and such has been observed is not always sufficient for a full understanding, and the subject is doubtless of vital interest.

The writer has had opportunity to observe that desulphurization slags from furnaces, where the slag was only heated from beneath, showed distinct traces of calcium carbide, and in these cases the elimination of the sulphur was very thorough, down to 0.008 per cent or thereabout; but as far as the writer is aware, this was partly due to the fact that such substances as would cause a kind of thermit reaction were added to the slag at the end of the melt, whereby the local temperature of the slag blanket was raised, thus altering the heat gradient between the metal and the slag in such direction as to obtain the result mentioned.

The quantity and nature of the material used were such as not to materially increase the cost of the operation; but this is not the point of issue, the question is—is it metallurgically possible to effect a thorough elimination of the sulphur when the metal is hotter than the slag?

It should be well understood that it is not the object of these lines to discuss the merits and disadvantages of any particular furnace principle, but the general question of refining with a metal hotter than the slag or vice versa is of sufficient importance to deserve a clearing up.

Reverting to the "pinch effect," it may be noteworthy that such effects may also, under circumstances, be observed in arc furnaces as will be seen from the following observations made by the author.

In an open-type reduction furnace, where only one top electrode and a bottom electrode were used, with single-phase current at 25 periods with 3500 amp, a slag layer about 7 in.

deep over the metal could be made to show the influence of the pinch effect in a marked degree. If the slag and reaction zone, for certain reasons, was made decidedly acid by adding a larger amount of quartz sand than usual, and then was so treated as to materially free it from metallic oxide, the ammeter began to swing over a large range.

At first it was thought that this was due to a temporary, violent reaction in the bath, but on closer observation it was found that the resistance of the slag was very much increased, which was natural, and that the current, instead of being more equally distributed over the whole bath, was concentrated to a narrow path under the electrode. At times it could be clearly seen how this path was contracted and the current interrupted for a moment, after which it again closed for a few minutes, when the phenomenon was repeated. During the whole time the voltage in the furnace was about 30 per cent higher than usual. The effect was clearly due to the "pinch" phenomenon.

By adding a shovel or two of metal oxide, thus increasing the conductivity of the charge and slag, the surging ceased, in spite of the more violent reaction. Also, by altering the nature of the slag through the addition of lime, all fluctuation was avoided.

This would indicate that a slag rich in SiO_2 is a less good "second-class" conductor. A true lime silicate, or a slag richer in CaO , seems to be a better second-class conductor, while, of course, the presence of free metallic oxides, such as iron oxide, etc., will sufficiently increase the conductivity to stop the pinch effect. But as this would mean a slag richer in metal, and also an unstable condition on account of the metal being constantly reduced, it seemed advisable not to employ, a too acid slag, though its merits may otherwise justify such course.

JOH. HÄRDÉN.

Luton, England.

American Institute of Chemical Engineers

Report of Boston Meeting

The fifth semi-annual meeting of the American Institute of Chemical Engineers was held in Boston, Mass., from June 25 to 28. The sessions were held in the Engineers Club. The meeting was opened by an address of welcome by Mayor Fitzgerald who spoke of the need of the services of technical men in solving municipal problems. Mr. Frederick P. Fish also addressed the Institute on behalf of the Massachusetts Institute of Technology.

The report of the secretary showed an increase of membership of 17 during the past half year, the total membership being 195, while 13 applications had not been acted upon.

The Patent Committee offered a resolution to President Wilson asking him to appoint a committee of experts to examine the patent system and recommend needed legislation. This resolution is printed at the end of this report.

A resolution was adopted indorsing the action of Secretary Lane in recommending Thos. E. Ewing for the position of Commissioner of Patents.

A resolution was also adopted addressed to the Senate, urging the confirmation of the appointment of Thos. E. Ewing as Commissioner of Patents and the hearty support of the new commissioner in the great work he has to do.

The paper by Wm. M. Booth of Syracuse, N. Y., on The Effect of Climate on Plant Location proved very interesting, the effect of temperature, humidity, rainfall, etc., being discussed.

Mr. Perry Barker of A. D. Little, Inc., in a paper on Distribution of Heat in the Operation of Steam Boilers, gave a number of interesting cases in which losses were reduced and efficiency increased.

In the afternoon two parties were formed to visit the U. S. Arsenal at Watertown and the laboratory and experimental paper mill of Arthur D. Little, Inc. The latter proved of special interest as all the machinery of a modern paper mill had been reproduced in miniature so that experimental runs of paper could be made.

The second party visited the works of the Hood Rubber Co., which is an up-to-date, well-managed plant producing rubber boots, shoes and automobile tires. All parts of the process were shown from the washing and rolling of the crude rubber to the completion of the finished product. The plant was clean and working conditions for the employees excellent. Some of the rooms were provided with ozonizers to remove odors and purify the air.

After dinner at the Engineers Club the papers of the evening were presented as after dinner addresses.

President T. B. Wagner addressed the Institute on Efficiency in Chemical Industry, speaking particularly of the many notable advances which had been made in the manufacture of corn products. Beginning as a very wasteful industry one by-product after another had been utilized until now 99½ per cent of the raw material is converted into useful products. While the price of corn has risen five fold the cost of starch has fallen three fold. This very interesting address is published in full elsewhere in this issue.

Dr. Louis J. Matos presented a very interesting paper on General Efficiency in Dye Houses and Bleach Works, while Dr. Grosvenor in his paper on Relation of the Manufacturer to the Patent System showed the very great influence which the United States Patent System has exerted in building up our industries.

All day Thursday was spent at Lawrence, Mass., where the mill of the Russell Paper Co. and the wool scouring, spinning, weaving and bleaching department, as well as the cotton mill of the Pacific Mills were visited. The enormous size of these mills is indicated by the fact that the woolen mill turns out about 12,000 pieces of 50 yd. each per week, while the capacity of the cotton print works is 700,000 yd. per day. The sample cards alone of this mill consume 1,000,000 yd. of cloth. The floor space of the print works is 1,500,000 sq. ft.

The bleaching as well as the printing of the cotton cloth was inspected, as well as the etching of the designs on the copper rolls used for printing the cloth. The working conditions in this mill seemed ideal, light and air being provided in abundance and cleanliness.

After dinner at the Engineers Club the following papers were read. Low and Mixed-Pressure Turbines was read by John G. Callan of Arthur D. Little, Inc. Very great interest was shown in the demonstration of the possibility of using the exhaust steam in low pressure turbines so as to increase the power developed by 50 per cent. The author pointed out that in spite of the great efficiency of the low-pressure turbine, it was more economical to use the exhaust steam for heating purposes as is generally possible in chemical plants.

Legal Control of Dangers to Health in Factories by Dr. Chas. F. McKenna was then read. Practical suggestions were made of laws which should be enacted for the purpose of remedying existing evils. As a part of this paper a standard legislative bill was presented which has been passed by the legislatures of fifteen states with reference to occupational diseases. This bill is published at the end of this report.

In the paper by Dr. F. W. Frerichs on Import Duties on Chemicals and Their Influence on Chemical Industry the danger to a number of existing industries from unwise legislation was pointed out.

On Friday morning at 9 o'clock the members of the Institute and their guests embarked on the ocean-going tugboat *Pallos* and were conveyed to the pier of the New England Gas and Coke Co. at Everett. The admirable equipment for unloading coal was first inspected. This consists of seven towers equipped with scoops of the clam type which are capable of taking 5000 tons of coal from the hold of a steamer in two hours. A train of cars is filled and emptied automatically distributing the coal to the bins or storage piles as desired. In addition to the 600,000 gross tons of coal carbonized at this plant annually 1,000,000 tons of steam coal are handled. The coke ovens were then inspected as well as the ammonia recovery plant and the gas purifying apparatus. All of the gas used by Boston is supplied by this plant.

The party then reembarked on the towboat for the trip to Marblehead. As the day was warm the ocean trip proved very enjoyable. Marblehead was reached at about 1 o'clock. Dinner was taken at the New England Yacht Club. President Wagner presided at the dinner and introduced various speakers between the courses. He first called upon the first president, Dr. Samuel P. Sadtler who spoke of the growth of the Institute since its organization, having increased its membership 500 per cent. Mr. Henry Howard, chairman of the Local Committee, was then called upon, after which Mr. John V. N. Dorr, of Denver, Col., who had come East to attend the meeting, spoke of conditions in the West, especially the mining and metallurgical industry. He suggested the possibility of utilizing in widely different industries apparatus which had been developed in special metallurgical industries. Mr. John C. Hebden, of Providence, closed the program with a number of very amusing anecdotes.

The party then adjourned to the spacious verandas of the club where cigars and the beautiful view of the harbor were enjoyed. The return to Boston was made on the towboat ending a very enjoyable trip.

After a light supper at the Engineers Club the following papers were read: Depreciation and Obsolescence by Richard K. Meade, of Baltimore, Md. In this paper the author discussed in a very thorough manner the allowance which should be made for wear and tear as well as obsolescence in chemical plants, especially cement mills.

Professor Wm. P. Mason, in a paper entitled A Peculiar Case of Lake Pollution, showed how typhoid bacteria were carried 10 miles, the entire length of one of the needle lakes of New York State, and produced a very severe epidemic of this disease.

A paper by J. C. Olsen and A. H. Callaghan on The Drying of Linseed Oil with Red Lead and White Lead was then read. The authors had determined the amount of water and carbon dioxide given off during the drying of red lead and white lead paint. They found that with the same absorption of oxygen very much smaller amounts of water and carbon dioxide were given off by the red lead paint than by the white lead paint or pure linseed oil. This was suggested as an explanation of the superiority of the red lead paint as a protective coating for iron and steel.

New York was chosen as the place for the annual meeting which will be held during the first half of December.

After the usual resolutions of thanks, the Institute adjourned.

On Saturday two plants in Providence, R. I., were visited. One of these was the United States Finishing Co. where the processes of bleaching, dyeing and printing were inspected. The other plant visited was the Gorham Mfg. Co. where the manufacture of solid silver and silver plated table and ornamental ware was inspected. The standard thickness of silver plate in this plant is 1/1000 in.

About 1 ton of silver is used daily. The casting and finishing of large bronze statues was inspected with great interest.

* * *

Patent System Reform

As mentioned above, a resolution to President Wilson was adopted asking him to appoint a committee of experts on the patent system. This resolution is as follows:

"To the Honorable Woodrow Wilson, President of the United States:

"Whereas, the patent system of the United States has had an immense influence on the industrial development of this country, by stimulating competition by improvement, beneficial to the consumer as well as to the producer.

"Whereas, our patent system has become inadequate to cope with the rapid growth and changing conditions of the country so that now it seems imperative that the different departments of our patent system should be modified to meet the new conditions,

"Whereas, inadequate and harmful legislation is apt to result unless the subject is given mature and competent consideration.

"Resolved, the American Institute of Chemical Engineers does hereby respectfully call the attention of the President of the United States to the urgent need of appointing a competent commission to investigate thoroughly the United States patent system, and to prepare a report and submit recommendations before the passage of any legislation bearing on this delicate and complicated subject; the American Institute of Chemical Engineers, furthermore, suggests, that such a commission should be composed of men who are best acquainted with this subject, as well as representatives of all the important interests affected by the patent system, such as the courts, inventors, technologists, manufacturers and patent attorneys.

"American Institute of Chemical Engineers.

"T. B. Wagner, President; J. C. Olsen, Secretary."

* * *

Bill on Occupational Diseases

As part of Dr. McKenna's paper mentioned above, a legislative bill, which has been passed by the legislatures of fifteen states, was given. This reads as follows:

"An act to require the reporting of certain occupational diseases and to provide for its enforcement.

"Be it enacted, etc., as follows:

"Section 1—Report of Occupational Diseases:

"Every physician in this state attending on or called in to visit a patient whom he believes to be suffering from poisoning from lead, phosphorus, arsenic, brass, wood alcohol, mercury or their compounds, or from anthrax, or from compressed air

illness, or any other ailment or disease contracted as the result of the nature of the patient's employment, shall within forty-eight hours send to the state board of health a report stating:

"(a) Name, address and occupation of patient.

"(b) Name, address and business of employer.

"(c) Nature of disease.

"(d) Such other information as may be reasonably required by the state board of health.

"The reports herein required shall be on or in conformity with the standard schedule blanks hereinafter provided for. The posting of the report, within the time required, in a stamped envelope addressed to the office of the state board of health, shall be a compliance with this section.

"Section 2—Blanks for Reports:

"The state board of health shall prepare and furnish, free of cost, to the physicians included in Section 1, standard schedule blanks for the reports required under this act. The form and contents of such blanks shall be determined by the state board of health.

"Section 3—Reports Not Evidence:

"Reports made under this act shall not be evidence of the facts therein stated in any action arising out of the disease therein reported.



T. B. WAGNER

"Section 4—Penalty:

"Any physician who neglects or refuses to send the report or reports as herein required shall be liable to the state for a penalty of ——— dollars for each offense, recoverable by civil action by the state board of health.

"Section 5—Transmission of Reports:

"It shall furthermore be the duty of the state board of health to transmit a copy of all such reports of occupational disease to the (proper official having charge of factory inspection).

"Section 6—Time of Taking Effect:

"This act shall take effect on ———."

Dr. T. B. Wagner is the president of the American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the secretary.

The Western Metallurgical Field

Hydrometallurgy in Montana

Leaching processes for copper and zinc ores are attracting attention again and Montana is the scene of the greatest activity along this line in the United States. At Butte the Butte & Duluth company is leaching copper ores with sulphuric acid and precipitating the resulting solution electrolytically. In Anaconda an 80-ton experimental plant is being built at the Washoe smelter of the Anaconda Copper Mining Co., for the purpose of treating tailings from concentration of second-class ores. A third process is under way at Helena, where the Northwestern Metals Co. is developing a process for treating zinc ores by dry chlorination.

A peculiar fascination and interest attaches to hydrometallurgical processes, probably due to the fact that they are so easily demonstrated in a laboratory way. In this respect they resemble the schemes for electrolytic amalgamation, which seem to work so beautifully in a simple beaker test, but develop unconsidered difficulties on a commercial scale. Mechanical problems in the way of handling solutions and noxious gases are usually regarded as the greatest obstacles to hydrometallurgical success. This is particularly true in the treatment of base metal ores, where pounds of metal must be dissolved and precipitated, as distinguished from the cyanidation of precious metal ores which contain only ounces or fractions of an ounce of metal. Another difficulty lies in the necessary use of a solvent which affects several metals similarly, and thus extracts the undesirable with the desirable.

Experience with hydrometallurgy leads to the conclusion that it is applicable with success in special cases, and that a process profitably applied at one place cannot be adopted without alteration in another locality. Thus each proposition must be considered individually, and a process devised that will meet the peculiar needs of each, if such a thing is possible. Natural conditions sometimes favor hydrometallurgy, presenting an ore free from deleterious elements that will foul the solutions, or offering special advantages in the way of cheap power, or acid that can be made as a by-product from other operations.

But if these processes are not of universal application, they are none the less admirable in the special cases in which they are successful, because they frequently provide a means of treating ores and products that would not be handled by standard methods and thus conserve a valuable mineral resource.

The Anaconda experiment is based on a process devised by Mr. Frederick Laist, superintendent for the Anaconda Copper Mining Co. It will be applied to the recovery of copper from concentration tailings. The steps in the process include a roast with salt to render the copper soluble and extraction with dilute sulphuric acid. Precipitation will be by hydrogen sulphide. The reactions involved are simple and the chemicals required can be obtained without great cost. Salt is inexpensive; sulphuric acid can be made by the chamber process as a by-product of roasting concentrates, and hydrogen sulphide can be generated by the action of sulphuric acid on iron matte, the latter being cheaply produced from iron ores in the district. A question has been raised as to the use of hydrogen sulphide on account of its poisonous nature and the possibility

of resulting accidents; but in view of its former extensive use in the chlorination process, the objection seems not important.

The dry chlorination of zinc-lead ores at Helena is one of several experiments of a similar kind that have been considered for several years. Chlorine gas is the active agent employed in attacking the ore and rendering the metals soluble, after which they are recovered by steps in precipitation which are susceptible of considerable variation. It is expected that experiments on a commercial scale will be commenced this summer, and pending the actual operation of the process, no definite information is available for publication. The results will be awaited with interest, for the process has a distinct bearing on the low-grade, complex ore problem. Success at Helena will be encouraging, but failure will not necessarily mean that dry chlorination in the hands of other investigators may not prove successful.

Recovering Sulphur from Smelter Fume

The past few years have been rich in effort and experiment to eliminate sulphur and sulphurous products from smelter fume, and thereby remove the great bone of contention between smelting and agricultural interests. Methods of neutralization followed by bag-house recovery have been proposed and adopted, as also has been the Cottrell process of electric precipitation. In METALLURGICAL AND CHEMICAL ENGINEERING for November, 1912, the Thiogen system of fume control was described, which has been experimented with at the Penn Chemical smelter, Campo Seco, Cal. This process aims to produce elemental sulphur from roaster gases by reducing the sulphur dioxide with carbon contained in an oil spray and passing the mixture over calcium sulphide. Although the usual mechanical difficulties have been experienced in applying this process, it is understood that the prospect is so favorable for its success as to warrant the company erecting a new roasting plant of Wedge furnaces and the necessary equipment for the treatment of the roaster gases.

More recently another process, devised by Mr. William A. Hall, has been announced and is about to be tried in California, where the smelting industry has been seriously handicapped by conflict with the farmers. **The Hall process** takes a step in advance of all others by preventing the formation of oxidized sulphur gases which must be subsequently reduced or neutralized. Mr. Hall's scheme involves the direct distillation of sulphur from the ore and its recovery in some suitable form of gas washer. Thus the problem apparently is attacked in the most direct manner, avoiding intermediate steps of oxidation and reduction.

Distillation in the Hall process depends on roasting ore at a temperature between 700 deg. and 900 deg. C., by the direct application of a reducing, or at least non-oxidizing flame, together with the introduction of a certain amount of water in the form of steam. Under these conditions the base metals are oxidized and the sulphur distilled without combining with oxygen and can be easily collected.

The technical success of the process still leaves unsolved the interesting problem of the disposal of the product. The net consumption of sulphur in the United States in 1911 is given as approximately 200,000 tons, or, in round numbers, 500 tons per day. Considering the magnitude of modern smelting operations, it is conceivable that the application of the Hall process at one or two plants might easily produce more sulphur than is now consumed. And if the cost of production were low, which it may be, the output would seriously affect the market for present producers. Of course, there is always the prospect that cheaper production would stimulate consumption and thus take care of an increased output; but with the wide adoption of the process in this country and abroad it is conceivable that the sulphur market would be promptly glutted. The prospect is similar to that which would result from converting all our smelter fume into sulphuric acid; it could not be utilized and its disposition would become a serious matter. Nevertheless the Hall process is a welcome addition to metallurgy, and its results will be awaited with great interest.

Dry Ore Dressing

A stimulus has been given to dry processes of ore dressing by the invention and promotion of several machines which apparently have a legitimate field of usefulness. Mention has been made in this journal of the complete experimental plant which the **Sutton, Steele & Steele** company has erected in Denver for the demonstration of dry concentrating tables and electrostatic separators. Ample financial support has been given to the processes of this company and has resulted in arousing an interest in dry methods of ore treatment such as has not been manifest for some time. The machines and processes are not entirely new, but have not been widely advertised, and the construction of the present plant is expected to call attention more strongly to the possibilities of dry ore dressing and the advantages of that system in some localities.

An entirely new departure in this field is the dry jig developed in Denver by Mr. **A. M. Plumb**. A pulsating current of air is applied to the jig bed similar to the pulsations of water in wet jigging, and a remarkably clean separation of mineral and gangue, or mixed minerals, results. Used in connection with electrostatic separation or wet dressing, the machine is an accessory which seems to occupy a field of usefulness that has been neglected. The jig has its limitations, chief among which is its inability to separate products ground finer than 150 mesh; but it has the desirable qualities of being practically foolproof and positive in its action. A machine of commercial size has a jigging box about 24 in. long by 6 in. wide and occupies only a small space. A great variety of ores and mill products have been tested and the jig will be placed on the market this summer. One of the first installations will be made at the Sunnyside mill in Silverton, Col.

Rochester Meeting of the American Chemical Society

The 48th annual meeting of the American Chemical Society will be held in Rochester, N. Y., from September 9th to 14th.

The program will open with a general meeting on Tuesday at 10 a. m. in the assembly hall at Kodak Park; in the afternoon the works of the Eastman Kodak Co. will be visited; in the evening there will be a smoker.

Divisional meetings will be held on Wednesday all day, and on Thursday and Friday in the morning at the University of Rochester. The President's address will be given at the East High School on Wednesday night, and a subscription dinner will be held on Thursday night.

Dr. Charles L. Parsons, Box 505, Washington, D. C., is the secretary of the American Chemical Society.

Butte Meeting of the American Institute of Mining Engineers

The 105th meeting of the American Institute of Mining Engineers will be held at Butte, Montana, beginning Monday, August 18th, 1913, with a stop-over at Great Falls, on August 16th.

On Monday, August 18th, technical sessions will be held in the morning and evening, while visits to the mines are arranged for the afternoon.

Tuesday, August 19th, will be devoted to a trip to Anaconda and the Southern Cross mine, while an entertainment is scheduled for the evening.

On Wednesday, August 20th, technical sessions will again be held in the morning and evening, while visits to mines and smelters will be made in the afternoon.

On Thursday, August 21st, the concluding technical session will be held in the morning, while for the afternoon visits to mines and for the evening a banquet are being arranged.

Charles W. Goodale is chairman of the general committee in charge of the meeting.

Bradley Stoughton, 29 West 39th Street, New York City, is the secretary of the American Institute of Mining Engineers.

Colorado Meeting of the American Electrochemical Society

The twenty-fourth general meeting of the American Electrochemical Society will be held in Denver on Sept. 9, 10 and 11, 1913.

The special train with the Eastern members is expected to arrive at Denver on Monday afternoon, Sept. 8. Automobiles will take the party for a ride about the city's comprehensive park and boulevard system, finishing at the Hotel Shirley, the Society's headquarters. In the evening of Monday there will be registration, a meeting of the Board of Directors and a general good time of getting together.

Tuesday, Sept. 9—A morning session will be held in Denver for the reading and discussion of papers. For the afternoon various visits are being arranged. In the evening an informal smoker will be held.

Wednesday, Sept. 10—An early car will be taken for Boulder, where a session for the reading and discussion of papers will be held at the University of Colorado. After lunch automobiles will be taken up Boulder canyon to the power plant of the Central Colorado Power Company, at the entrance to the Boulder tungsten district.

Thursday, Sept. 11—In the morning a session will be held for the reading and discussion of papers at the School of Mines in Golden. For the afternoon various visits are being arranged. In the evening an informal picnic dinner will be held on Look-out Mountain, just west of Denver, behind Golden.

The program of papers to be presented and discussed in the three sessions at Denver, Boulder and Golden will be announced in the next *Bulletin* of the Society. The potentialities of the applications of electrochemistry in Western metallurgy will naturally be prominent in the program.

Various visits are being arranged to places of great natural beauty and picturesqueness as well as to chemical and metallurgical works; there will be much of interest and also some matters of decided novelty.

For the ladies' entertainment during the three days in Denver a trolley ride to the Foot Hills of the Rocky Mountains, a luncheon and a theater party have been outlined with other rides and visits to places of interest.

Friday, Sept. 12—In the morning the return trip will be begun which will take the party first to Colorado Springs, where the forenoon will be spent in a visit to the Garden of the Gods or places of metallurgical interest. In the afternoon a trip will be made up Pike's Peak, where it is intended to hold the concluding session of the meeting, the program of which will be announced in the next *Bulletin* of the Society.

Saturday, Sept. 13—A further side trip will be made from Colorado Springs over the magnificent "Short Line" into the gold district of Cripple Creek.

On Saturday night the special train will start from Colorado Springs on the return trip to the East.

According to present indications the attendance will be large and it is hoped that it may be possible to start a special train right from New York City. The trip from New York to Denver will be made over the New York Central and Burlington lines, the return trip on the Sante Fé. The train will be composed of the highest grade Pullman equipment, drawing-room, compartment, observation and dining-cars; also a combination buffet smoking-library car with barber shop and bath. The entire train will be electrically lighted and all steel equipment will be used.

The complete schedule of the special train (which will be the first electrochemical train ever arranged) will be published in detail with connections from other cities, details of fares, in a pamphlet to be issued shortly.

The special train will leave New York City from Grand Central Terminal on Saturday, Sept. 6, at 10.30 a. m., arrive Chicago on Sunday, 7.59 a. m., leave Chicago at 9.45 a. m. and arrive in Denver on Monday, Sept. 8, at 1.15 p. m.

The return train will leave Colorado Springs on Saturday, Sept. 13, at 10.30 p. m. (Western time), arrive Kansas City on

Sunday at 6.55 p. m., leave at 7.30 p. m., arrive Chicago on Monday at 9.15 a. m., (Central time), leave Chicago at 10.15 a. m., and arrive in New York City on Tuesday, Sept. 16, at 9.11 a. m.

All requests for Pullman car reservations and railroad transportation should be made to the chairman of the Transportation Committee, Mr. J. M. Muir, 239 W. 39 Street, New York City, from whom any additional information concerning transportation may be obtained.

Dr. J. W. Richards, Lehigh University, South Bethlehem, Pa., is the secretary of the American Electrochemical Society.

International Electrical Congress, San Francisco, 1915

Preliminary plans for the International Electrical Congress which is to be held in San Francisco during the week beginning September 13th, 1915, in conjunction with the Panama-Pacific International Exposition, and under the auspices of the American Institute of Electrical Engineers, are being effected by the Committee on Organization.

In the week preceding the Congress there will be a meeting of the International Electrotechnical Commission.

The Congress is being divided into twelve sections, as follows:

1. *Generation, Transmission and Distribution.*—Central station and substation design, control and operation. Long distance transmission of electric power.
2. *Apparatus Design.*—Generators, motors and transformers. Prime movers and their relations. The rating of machinery.
3. *Electric, Traction and Transportation.*—City, surface and rapid transit railways; interurban and trunk lines; electric vehicles, ship propulsion, mining, railways, elevators and hoists.
4. *Electric Power for Industrial and Domestic Use.*—Factories, mills, refrigeration, heating devices, etc.
5. *Lighting and Illumination.*—Arc and incandescent lighting; the science and art of illumination.
6. *Protective Devices; Transients.*—Switches, circuit breakers; condensers; electrostatics; disruptive phenomena; high frequency phenomena.
7. *Electrochemistry and Electrometallurgy.*—Electrolytic and metallurgical apparatus and processes.
8. *Telegraphy and Telephony.*
 - (a) All communication of intelligence by the use of wires.
 - (b) Electromagnetic waves and radio telegraphy and telephony.
9. *Electrical Instruments and Electrical Measurements.*—Switchboard, portable, standard and absolute instruments. Testing and standardization methods; absolute measurements.
10. *Economics of Central Stations and Systems.*—Load factors, power factors and all problems affecting the economy of central stations; also rates and regulation by public service commissions.
11. *Electro-Physics.*—Radioactivity; Röntgen rays; gas and vapor conduction; electron theory; constitution of matter.
12. *Miscellaneous.*—Such as history of literature of electrical engineering; symbols and nomenclature; engineering education and ethics.

In each section it is desired to include as many as practicable notable papers dealing with the status or the progress of the art. Offers of papers and suggestions in this connection should be directed to the Secretary of the Committee on Organization, Dr. E. B. Rose, Bureau of Standards, Washington, D. C.

The Non-Ferrous Metal Market

During July the market for non-ferrous metals has been dull and decidedly weak in some cases. The usual midsummer dullness has dominated the market generally and in the case of tin the conditions abroad have thoroughly unsettled the domestic market. Spelter has rallied somewhat, and the present prices probably will forestall the further closing of mines and concentrating plants. Copper and lead have not shown much tendency to change.

Copper.—Buyers have not appeared anxious to enter the market, but it is believed that they cannot hold off much longer. Prices have been reduced in an effort to stimulate business but sellers of Lake brands have shown a disposition to stand by the fixed prices and await improvement in the market. Electrolytic is quoted at 14.20@14.25 and Lake at 14.45@14.50 cents.

Tin.—Continued liquidation in the London market for several weeks has resulted in greatly reducing the quotations for this metal and the continued decline has stopped buying in this market. The last quotations are unsettled and may go lower. July tin was quoted in New York at 39 cents.

Lead.—This market has remained unchanged since our last report. The St. Louis quotation is 4.17½@4.20 cents; New York, 4.20@4.35 cents.

Spelter.—There has been an improvement in the price for spelter since our last report. A curtailment in production has followed the closing of several mines and concentrators, but at last reports all inquiries for metal were being freely met. St. Louis prices are 5.05@5.15 cents and New York, 5.20@5.30 cents.

Other Metals.—Business in aluminium is light and prices are unsteady at 23@24 cents, New York. Antimony is quiet and prices are unchanged at 7.50 to 8.75 cents for various brands. The quicksilver market is quiet with prices at \$40 per flask of 75 lb., New York, and \$39.50, San Francisco.

Carrying the Injured in Accidents

It has recently been said, and is undoubtedly true, that there is at present such a strong tendency among the large American manufacturers to protect their employees against accidents that in this respect the manufacturers are willing to go to extremes. Nevertheless accidents will happen, and it is an important problem how to render first help in an accident.

With respect to the question of carrying an injured man safely away, "the splint stretcher" which has been devised after years of experimentation by Dr. C. F. Stokes, surgeon-general of the United States Navy, marks an important advance. The Stokes Splint Stretcher is a basket of heavy iron wire, properly braced, long and wide enough to accommodate a man, with nickel plated handles on the sides and at the corners. The braces also serve as runners when dragging the injured is the only way removal can be accomplished. Within the basket a partition extends from the foot and well up toward the center. This keeps the legs well separated and affords each an extra support. Since the majority of accidents needing a stretcher require bandaging of one or both legs, the advantage of this arrangement is obvious.

The construction and the method of handling are described and clearly shown in illustrations in a little bulletin of the Kny-Scheerer Company, 404 West 27th Street, New York City.

It is perhaps interesting to note in this connection that this "splint stretcher" has first found extended use among the copper mining companies, being employed in not less than six of the large copper companies of Arizona, like the Inspiration, Copper Queen, etc. More recently it is being introduced also by various iron mining companies.

Flotation in Arizona

Interesting progress of the flotation process is reported from Arizona. The Inspiration Consolidated Copper Company has had for some time a comparatively large experimental plant in operation, using the Minerals Separation process, with a capacity of 50 tons daily.

The results have been so encouraging that the Inspiration Company is now going to build a larger plant of 600 tons daily capacity. This is expected to be in operation in about six months.

A detailed and fully illustrated description of the Minerals Separation Flotation process, as worked at the Kyloe Copper Mines, N. L., was given in a paper by H. Hardy Smith in the March issue of this journal, page 131.

Cyanide Practice in the Black Hills, South Dakota.—II.

By H. C. Parmelee

Bismarck Consolidated Mill

Practice similar to that at the Wasp No. 2 mill, described in our last issue, is to be found at the mill of the Bismarck Consolidated Mines Co. Conditions at these two adjoining properties are similar in that the ore is low-grade, \$2 to \$2.50 per ton, and is readily amenable to cyanidation by leaching when crushed to $\frac{1}{4}$ in. The Wasp and Bismarck mills are the only two now operating in the Black Hills following the practice of dry crushing and sizing. The Bismarck ore is oxidized and offers few obstacles to successful cyanidation. In crushing it probably produces more fine material than does the coarse quartzite of the Wasp No. 2, but not sufficient to cause serious difficulty in leaching.

The mill site is a rather steep hillside, and the mill is built in terraces, with separate bins for the storage of ore at the head of the coarse-crushing, fine-crushing and leaching departments. The building is of frame construction and well lighted, and the interior arrangement is such that all machines are readily accessible for inspection and repair. Electric power is used throughout, separate motors being conveniently arranged for the operation of the different departments. The capacity of the mill is 300 tons per 24 hours.

Coarse Crushing in Gyratories

Ore from the different mine workings is delivered to a 500-ton bin at the head of the mill. The initial breaking is done in a No. 5 Gates Gyratory which reduces the ore to 3-in. size, this product being delivered onto a 22-in. belt conveyor, 28 ft. centers, running at an inclination of 21 degrees. The belt discharge is split and flows over two grizzlies arranged in the form of an inverted V. These are each 2 ft. wide by 6 ft. long, and have $1\frac{1}{2}$ -in. openings. The oversize passes directly to two No. 3 Gates gyratories, where it is crushed to $1\frac{1}{2}$ in. and combined with the grizzly undersize. An 18-in. belt and bucket elevator, 35 ft. centers, running at 250 ft. per min., raises the crushed ore to the roll-bin of 400 tons capacity. The three gyratories, conveyor and elevator are all operated from one line shaft driven by a 75-hp. motor.

Rolls are used as secondary crushers. From the roll-bin the ore is delivered by a shaking feeder to a set of 15 in. by 36 in. rolls which crush to about $\frac{1}{2}$ or $\frac{3}{8}$ in. This product is elevated in a 16-in. belt and bucket elevator, 51 ft. centers, running at 297 ft. per min., and is delivered to a shaking screen vibrating 240 times per min. The screen is of woven wire, 2 ft. by 7 ft. in area, with apertures $\frac{1}{4}$ in. by 1 in. The undersize is a finished product and passes to a bin of 500 tons capacity, while the oversize is returned to a second set of rolls similar to the first, where it is crushed to $\frac{1}{4}$ in. and again elevated to the screen. The rolls and elevator are driven by a 65-hp. motor.

Leaching Vats Filled by Belt Conveyors

The leaching department contains six vats arranged in two rows of three each, across the mill. Five of the vats are 28 ft. diameter by 9 ft. deep, and have 216 tons capacity; the sixth is 30 ft. diameter by 12 ft. deep, and has a capacity of 334 tons. They are filled by a system of conveyor belts. No. 1 belt runs parallel with the crushed-ore bin, from which it receives ore through four rack and pinion gates. The ore is discharged onto No. 2 belt, running at right angles with No. 1, and extending over two vats, one at the end of each row. Belts Nos. 3 and 4 run at right angles with No. 2, extending over the other two vats in each row. By this system it is possible to divert ore from one belt to another, and thence to any of the six vats. Each conveyor is driven at a speed of 300 ft. per min. by a separate 3-hp. back-gear motor. The capacity is from 75 to 100 tons per hour. The dimensions of the belts are as follows:

Belt No.	Width Inches	Centers Feet
1.....	22	52
2.....	20	47
3.....	20	60
4.....	20	60

Leaching Practice

The method of applying solution to the ore differs from that used in other mills in the district. While the leaching vats are being filled with ore, 5-lb. cyanide solution is forced through the false bottom of the vat, at a rate which causes it to rise with the ore, but never to come above its surface. When the tank is filled and leveled, the moisture in the ore is estimated, and enough cyanide is dissolved on top of the charge to bring the strength of the solution up to five pounds per ton. The ore is covered to a depth of two or three inches with solution, and allowed to stand six hours before the leaching cock is opened. When the 5-lb. solution has nearly all percolated through the charge, the cock is closed and the ore is flooded with 4-lb. solution. As soon as air bubbles cease to appear at the surface, the leaching cock is opened and percolation proceeds. The ore is kept covered with solution until 24 hours have elapsed following the first covering with 5-lb. solution, and then allowed to drain. After this the vats are flooded at intervals with 2.5-lb. solution for a period of 72 hours, and allowed to drain before the application of wash water. From 35 to 45 tons of wash water is applied to each vat, and from 16 to 24 hours is required to thoroughly wash and drain a vat.

On account of the situation of the mill with reference to the railroad, and the consequent lack of room for tailing dump, it is necessary to unload the vats by hand and stack the tailing dry. Each vat has four discharge gates in the bottom, through which tailing is shoveled into cars beneath, and trammed to the dump. From 14 to 16 hours time is required to dump and fill a vat.

All water used in the mill flows by gravity from the mine to storage tanks placed on a level with the crushing floor of the mill. Storage tanks for strong and weak stock solutions, and gold solution, and sump tanks for barren and weak solutions, are suitably placed. Two 5 by 6 Deming triplex pumps are used to transfer barren and weak solutions from sump to stock tanks. Solutions are standardized to proper strength in the stock tanks, and drawn to the leaching vats as required. Lime is added dry at the large gyratory, being shoveled in with ore at the rate of about six pounds per ton.

Precipitation on Zinc Shavings

The zinc boxes have a combined capacity of 98 cu. ft. of shavings, and under present operating conditions the quantity of solution precipitated averages 160 to 170 tons per 24 hours, or about 1 ton per ton of ore treated. Only strong solution is precipitated; the gold-bearing weak solution is pumped back to the strong solution stock tank as required to maintain the necessary volume for leaching.

The strength of solutions has already been indicated: 4 to 5 lb. KCN per ton for strong, and 2.5 lb. for weak. Protective alkalinity is maintained at 0.8 to 1.2 lb. CaO per ton. During the month of April, 1913, the chemical consumption per ton of ore treated was: CaO, 6 lb.; Zn, 0.405 lb.; KCN, 0.402 lb. The mill has not been in operation long enough to determine what the average extraction should be, but thus far it has ranged from 70 per cent to 89 per cent on individual vats.

The value of ore and tailing is determined by sampling each vat before and after leaching. The tonnage of gold solution precipitated is estimated by a meter of the oscillating box type, placed below the zinc boxes. The tailing solutions from the several boxes are combined and flow through a launder in which is a smaller launder that cuts out $\frac{1}{10}$ of the stream and delivers it to the meter.

There are no unusual features in the clean-up and acid-treatment of the gold precipitate.

The New Reliance Mill

The cyanide practice at the mill of the New Reliance Gold Mining Co., near Trojan, S. D., presents some features which are unusual in the Black Hills. Some months ago the present management made important changes in the mill system, chief among which was the adoption of the continuous decantation system of slime treatment in Dorr thickeners, followed by

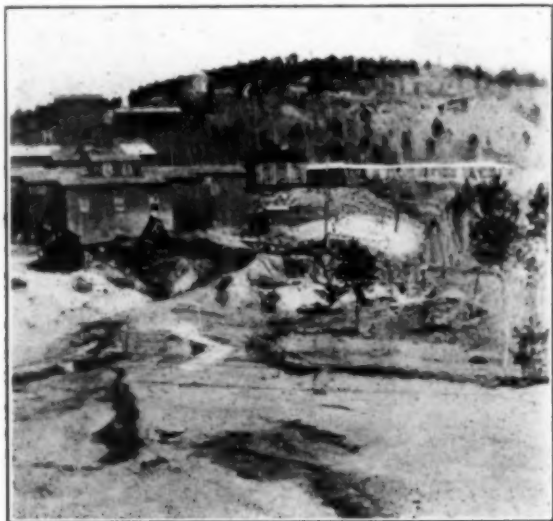


FIG. 1—NEW RELIANCE MILL, TROJAN, S. D.

vacuum filtration in a Portland rotary filter. In this respect the New Reliance mill is radically different from the other mills in the district. Another point of difference is the use of stamps instead of rolls and Chilean mills. Considering the simplicity of all operations in the slime department, and the general improvement in results obtained, the changes in the system appear to have been fully justified. A view of the mill and part of the slime pond appears in Fig. 1.

Crushing with Stamps in Cyanide Solution

Excluding the Homestake, the New Reliance is the only mill in the Black Hills using stamps. Rolls and Chilean mills are generally adopted, and while it is true that these machines are proving successful as grinders for very hard ores, nevertheless the higher extraction obtained on hard refractory ores at the New Reliance suggests one point of superiority of the stamp as a machine for crushing in solution. The agitation of the ore and solution in the stamp mortar is much more effective than in rolls or Chilean mills, and undoubtedly aids the process of solution, since it leaves less of the precious met-

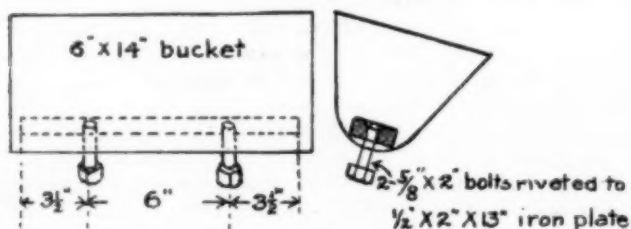


FIG. 2—BUCKET CLEANER

als to be dissolved in the subsequent sand and slime treatment.

The mill feed is a mixture of oxidized, semi-oxidized and hard blue ores, the latter constituting from 20 per cent to 30 per cent of the whole. The successful treatment of so large a percentage of blue ore is important, in view of the fact that formerly it was regarded as too refractory, and consequently was not mined to any great extent.

The ore is first crushed in a gyratory, and automatically sampled by a bucket sampler which cuts out about 1/100 of the feed. This sample is further crushed, and passed through Jones riffles to obtain a suitable sample for the assay office.

The gyratory product is elevated to the stamp bins by the ordinary belt and bucket elevator. Some trouble has been experienced on account of fine, moist ore packing in the elevator buckets, but lately that has been overcome by a simple device consisting of a plate of iron fitting in the bottom of each bucket, and loosely bolted in that position. The bolts are long enough to allow the plate a vertical movement of about an inch. The result is that when the bucket passes over the head pulley of the elevator to discharge its load, the plate falls and clears the bucket of ore. The device is shown in detail in Fig. 2.

Thirty 1000-lb. stamps dropping 96 times per minute through a height of from 6 to 9 in. show an average daily duty of 3 1/3 tons per stamp. Solution is used at the rate of 4 to 4.5 tons per ton of ore. A modified form of Challenge feeder is used, in which a more positive motion is imparted to the disc than

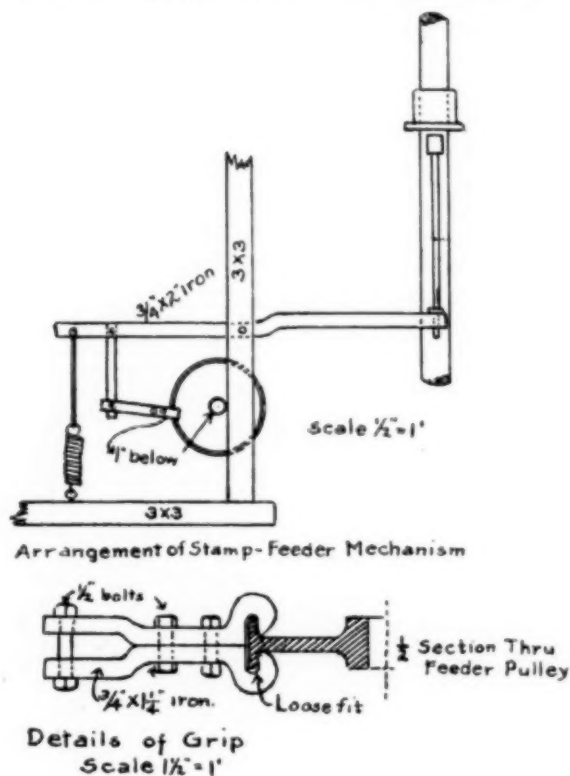


FIG. 3—RELIANCE STAMP-FEEDER MECHANISM

can be obtained by the usual friction band. The arrangement of the mechanism and details of the grip are shown in Fig. 3. The idea was suggested by the ease with which a pulley may be turned by gripping its edge with a monkey wrench.

Screen Analyses

The stamp mortars are fitted with No. 423 Ton-Cap screen, 0.023 in. slot. An average of 410 tons is passed through each screen before it is removed on account of wear. This appears to be a low average, but much of the ore is exceedingly hard and causes excessive wear on screens. The stamps yield a product having the following screen analysis:

Mesh	Per Cent
— 20 + 40	10.00
— 40 + 60	14.17
— 60 + 100	20.00
— 100 + 150	18.33
— 150 + 200	4.17
— 200	33.33
	100.00

The pulp is separated into sand and slime products in a Dorr classifier, a light spray of mill solution being applied to the sand just before it is discharged. From 60 to 65 per cent of the crushed ore is classified as slime, and 40 to 35 per cent

as sand. The following screen analyses show the efficiency of the separation:

Sand Product		Slime Product	
Mesh	Per Cent	Mesh	Per Cent
+ 40	27.50		
+ 60	25.00		
+ 100	28.34	+ 100	3.12
+ 150	14.17	+ 150	10.94
+ 200	1.66	+ 200	6.25
- 200	3.33	- 200	79.69
	100.00		100.00

Sand Treatment

The sand product from the classifier is leached in five 100-ton vats, which are filled by the ordinary revolving distributor. The first solution applied is the overflow from No. 1 thickener of the continuous decantation system. Percolation proceeds while the vat is filling, and commences as soon as clear solution can be obtained. This method of treatment yields a good grade of clear solution for precipitation, and eliminates the necessity of a clarifying tank ahead of the zinc boxes. A further advantage gained by leaching with the overflow from No. 1 thickener, instead of with mill solution, is that the former is clearer than the latter, and does not tend to clog the sand with slime.

When a vat is full, the charge is allowed to drain, after

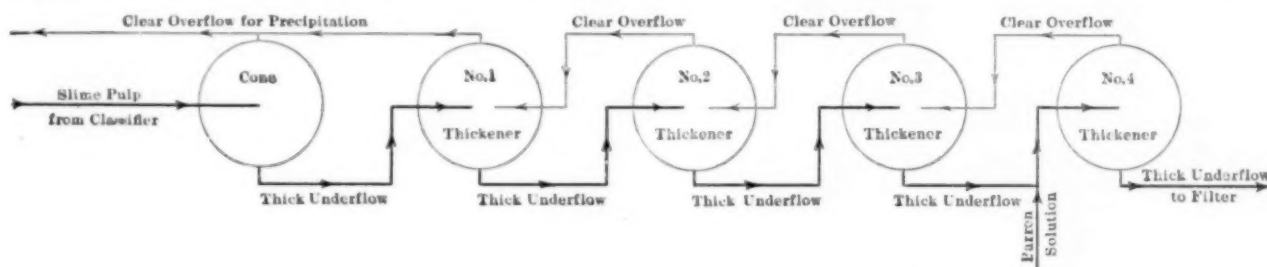


FIG. 4.—DIAGRAMMATIC REPRESENTATION OF CONTINUOUS DECANTATION TREATMENT FOR SLIME AT NEW RELIANCE MILL

which it receives successive washes of barren solution and water. The percolating solutions from both of these washes flow to the mill solution sump.

Continuous Decantation for Slime

The slime product from the Dorr classifier is subjected to continuous decantation and thickening, with counter-current washing, as outlined diagrammatically in Fig. 4. The thin pulp flows first to a 20-ft. cone which was part of the old mill equipment, and then successively through four Dorr thickeners in which the precious metal is dissolved, leaving a nearly barren pulp for final dewatering in a Portland filter. In order thoroughly to mix the pulp and solution flowing into any thickener, the launder in which these products are combined is provided with tapered or wedge-shaped baffles extending obliquely across the launder alternately to the right and left with a clearance of one inch between the lower end of the baffle and the side of the launder. Thus the pulp passing the lower end of any baffle is obstructed by the higher end of the next, which also changes the direction of the flow. The effect is to give every opportunity for the solution and solids to become thoroughly mixed before entering the thickener.

The feed to No. 1 thickener contains 80 per cent moisture, a ratio of solids to solution of 1:4. The underflow from No. 4 thickener carries about 55 per cent moisture, a ratio of 1:1.2. Washed slime pulp entering No. 1 thickener assays from \$1 to \$1.50 per ton, and the washed pulp discharged from No. 4 thickener runs from 40 to 80 cents per ton. These figures show wide variation, as also do the assays of the solutions overflowing the different thickeners, but they probably will be held within narrower limits when the new pumping system is installed, giving more perfect control of the flow of pulp.

The thickened underflow from No. 4 thickener, containing about 55 per cent moisture, passes to a Portland filter. In order to prevent settlement of solids in the filter tank, and to maintain the pulp at uniform consistency, the slime is circulated from the bottom of the tank through a diaphragm pump which discharges back to the tank. This action is supplemented once a day by inserting a compressed-air pipe into the filter tank, and scouring the bottom with a jet of air.

Steam Used to Clean Filter Cloth

An innovation in cleaning the filter cloth has been devised by Mr. F. C. Bowman, manager for the New Reliance company, consisting in the occasional use of steam to disintegrate the limey incrustation which clogs the filter pores. The steam, under about 10 lb. pressure, is introduced through the pipe ordinarily used for compressed air to discharge the cake, and that section of the filter through which the steam passes is lightly scrubbed with stiff brushes. By this method the lime is readily disintegrated, and thoroughly removed by a subsequent wash with hot water.

Before steam cleaning was adopted at the New Reliance, the customary acid treatment was used every two weeks; but at the present time, with even higher protective alkalinity in the solution than formerly, and with steam cleaning at intervals of two weeks, it has been necessary to resort to acid treatment only once in sixty days.

In the acid treatment a hot solution of 1 part commercial

hydrochloric acid and 5 parts water is poured over the filter from the top, while the machine is in motion and the vacuum on. The hot solution acts very quickly, being carried into the fabric and ultimately discharged by the vacuum pump. Only very slight scrubbing is required in places. By making suitable arrangement for applying the acid, the filter can be cleaned in twenty minutes.

A good quality of cotton cloth is used for the filter fabric, and the material is specially selected for freedom from flaws and irregularities in weave. The slight additional cost for specially selected material is warranted by the increased life of the cloth and better filtration. The cloth is placed on the drum with the finished side down, leaving the "wrong" or unfinished side of the cloth exposed. By this arrangement the slight nap or pile of the cloth produces a valve action in the meshes, being drawn inward when the vacuum is on, and forced out again when pressure is applied, leaving the pores clean and free.

As the dissolution of the precious metals is practically effected in the continuous decantation system, the chief function of the filter is to dewater the slime and discharge it to the dump. The average value of the whole pulp sent to the filter is from \$1.40 to \$1.60 per ton. The loss in dissolved gold is from \$0.05 to \$0.12, and the mechanical loss of cyanide is $\frac{1}{2}$ lb. per ton of dry slime. Vacuum is maintained at from 14 to 19 in., and the air for discharge of the cake is under a pressure of 10 lb. The slime cake has an average thickness $\frac{5}{16}$ to $\frac{3}{8}$ in., with extreme limits of $\frac{1}{4}$ to $\frac{1}{2}$ in. just before and after cleaning the cloth. The only wash applied to the cake is hot water coming from the jackets of the air compressor and flowing onto the descending side of the filter. The moisture in the filter cake will average 32 per cent, no attempt being made to discharge a dry cake, as about 40 per

cent moisture is required to carry the slime away from the mill. The filter is 12 ft. diameter with a 7.5 ft. face, and handles 65 tons of slime per day without reaching its full capacity.

Solution and Pulp Assays

The data given herewith refer to the month of May, 1913. The mill solution averaged 1.1 lb. KCN, with protective alkalinity at 1.5 lb. CaO. Higher protective alkalinity has occasionally been found desirable to reduce consumption of cyanide, and has been carried as high as 2.2 lb. CaO. Consumption of chemicals in pounds per ton of ore treated: KCN, 0.385; CaO, 6.25; Zn, 0.305. The value of the gold solution varies from \$1.20 to \$1.80 per ton; the zinc box tailing contains between 1 and 6 cents per ton. About 1¼ tons of solution is precipitated per ton of ore. The total cost of milling was \$1.234 per ton. This includes all labor, power, repairs, renewals, insurance, taxes, and general expense at the mill office.

The extraction as shown by bullion recovery is between 85 and 87 per cent. The sand tailing has an assay value of \$0.75 per ton, and the slime from \$0.55 to \$0.60. The difference between the two values is smaller than that observed at some of the other mills, and both are lower than some quoted elsewhere in these notes.

There are no unusual features in the methods of precipitation or clean-up. The gold solution is measured ahead of precipitation by means of an oscillating-box meter with counting attachment.

Power Data

The following tabulation gives the power consumption on the different groups of machines:

1 5K Gates gyratory crusher.....	} No load, 8 kw. Av. load, 11 kw. Extreme, 37 kw.
1 50-ft. elevator, 14 in. by 6 in. buckets.....	
1 16-in. belt conveyor, 22 ft. centers....	
Each 10-stamp battery.....	20 kw.
Dorr Classifier	0.36 kw.
1 5½ x 8 Deming triplex pump.....	} 10.25 kw. Each thickener requires about 0.075 hp.
1 5 x 6 Gould triplex pump.....	
1 4 x 6 Gould triplex pump.....	
1 7 x 6 Gould vacuum pump.....	
1 Portland filter.....	
4 Dorr thickeners, 20 ft. diameter.....	} 10.25 kw. Each thickener requires about 0.075 hp.
3 line shafts.....	

For the data given in these notes, and for courtesies extended while visiting the mills, I am indebted to Messrs. F. B. Hitchings and D. A. Elliott, of the Bismarck Consolidated Company, and Mr. F. C. Bowman, of the New Reliance.

A new alloy, consisting of manganese, titanium and silicon, has been patented by F. M. Becket, of Niagara Falls, N. Y. It may also contain carbon in proportions varying from a fraction of one per cent to sufficient quantity to furnish all or part of the carbon requisite in the recarbonization of steel. The manganese and titanium together are preferably in excess of fifty per cent of the alloy. When added to steel the component metals of the alloy are said to diffuse through the molten mass more uniformly and rapidly than do the corresponding ferro-alloys.

Utah Metal Production.—The total value of gold, silver, copper, lead and zinc produced in Utah in 1912 was \$42,922,302, according to advance figures by the U. S. Geological Survey. There was a decrease of 10 per cent in the value of gold produced, compared with 1911; an increase of 10 per cent in quantity of silver; a decrease in copper; an increase in lead, and about the same production of zinc. The total production showed an increase in value of about \$6,000,000.

A new soft-solder recently patented by John T. Dwyer, of St. Louis, Mo., is said to possess superior properties, and to be made at less cost than ordinary lead-tin solder. It contains approximately 41½ per cent tin, 0.02 per cent phosphorus, 2 per cent antimony, and the balance lead.

The Ostwald Process for Making Nitric Acid from Ammonia

Its Proposed Combination with the Manufacture of Calcium Cyanamide

The Ostwald process for making nitric acid from ammonia, which attracted considerable attention some ten years ago, has recently entered into a new stage of its commercial development in connection with the formation of the Nitrogen Products and Carbide Company, Ltd. This new British company issued in May a prospectus calling for a capital of \$10,000,000. Among its directors are Mr. Albert Vickers, Chairman of Vickers, Ltd., and Sir Richard Awdry of the Nobel Dynamite Trust Company, Ltd.

Among the products of this new company will be calcium carbide and calcium cyanamide, and the latter is to be employed to yield the ammonia needed as raw material for the manufacture of nitric acid by the Ostwald process. Use is here made of a well-known reaction by which ammonia is produced by heating cyanamide in presence of water $\text{CaCN}_2 + 3\text{H}_2\text{O} = \text{CaCO}_3 + 2\text{NH}_3$. (See, for instance, Erlwein, this journal, March, 1907, vol. V, p. 79). This reaction has been employed in some European works for the production of ammonium sulphate from cyanamide. The present proposal to work up the ammonia into nitric acid by the Ostwald process is novel.

The Ostwald process for making nitric acid from crude ammonia liquor is the subject of a long article in the *Iron and Coal Trades Review* (London) of May 23, 1913. This is reproduced in the following almost in full.

The fact that ammonia could be oxidized to nitric acid in the presence of atmospheric oxygen by the catalytic action of platinum was discovered by Kuhlmann about 1830. He was engaged in industrial work and, therefore, tried to apply this reaction in the commercial manufacture of nitric acid, but the time was an unfortunate one.

The great beds of sodium nitrate, on which we still depend for our nitric acid, were just being developed, and the price of nitric acid was falling rapidly in consequence.

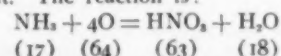
Besides this, there was no great production of ammonia or nitrogenous compounds, such as exists at the present time; by-product coke was not yet known, and there was no source of cheap ammonia.

The facts discovered by Kuhlmann, therefore, remained without commercial significance until within the last ten years, though the fundamental reaction, viz., the oxidation of ammonia to nitric acid in the presence of platinum, has been shown to every student of chemistry.

In 1900 Professor Ostwald and his assistant, Dr. Brauer, began to work on this same old reaction, having in view the application to a commercial process. At the end of about three years of investigation in the laboratory on a comparatively small scale, the process was considered ready for a test on a small commercial scale, and a year or so later the first commercial plant—a small one—was erected. This was studied with a view to the elimination of all possible sources of trouble and much time and labor have been spent in finding proper materials for the various parts of the apparatus, and in working out a completely automatic process.

About six years ago a full sized plant was begun, the results on the commercial experiment plant being by this time so satisfactory as to warrant the step. This large plant converted about 25 tons of ammonia gas per month into about 150 tons of rather dilute (36 deg. Baume) commercial nitric acid.

The chemical reaction is a very simple one. Ammonia gas mixed with air is passed over a plug of platinum, so arranged as to expose a large surface of contact to the gases which are forced through it. The reaction is:



For every seventeen parts by weight of ammonia used, 63 parts by weight of absolute nitric acid is formed.

Not long after the beginning of the experimental investiga-

tion of the reaction, an important fact was discovered. If the mixture of ammonia and air was allowed to pass slowly through the platinum contact, the yield of nitric acid was very small; only a few per cent of the theoretical yield was obtained.

If the stream of gas was forced quickly through the contact the yield was very nearly the theoretical value. This is to be explained by the fact that nitric acid is not the final product of the oxidation of ammonia, but only one of the intermediate ones. The final product is nitrogen gas and water.

So in the commercial plant the stream of ammonia mixed

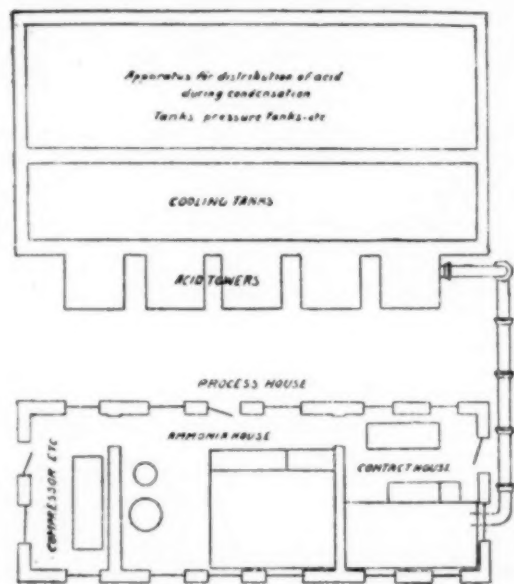


FIG. 1—GENERAL PLAN OF PLANT

with air is sent through the platinum contact plugs at a high rate of speed, and the result is a very high percentage of the theoretical yield, and a high efficiency of the apparatus used.

Dr. Ostwald in his patent No. 698, of 1902, describes his invention as follows:

"It is well known that nitric acid can be obtained from ammonia through the oxygen of the air by means of the catalytic action of spongy platinum or platinum black, although up to the present no process is known for thoroughly effecting this change in a useful technical matter. I have ascertained that under the influence of compact platinum alone, or platinum that is partly covered with spongy platinum or platinum black, a mixture of ammonia with an excess of air can be oxidized to nitric acid or to a higher oxide of nitrogen.

"Besides the oxidation of the ammonia to form nitric acid or higher oxides of nitrogen, another reaction usually takes place which leads to the formation of free nitrogen. In order, therefore, to attain a technically useful process the operation must be so conducted that the first reaction is thorough and practically complete, whilst the second should be as small as possible.

"This result is attained by using, for example, smooth or solid platinum which is either employed direct in this state or is first either partly or entirely coated with a layer of spongy or of black platinum. When now a mixture of ammonia with ten or more times the volume of atmospheric air is directed over it, a fairly high velocity being maintained, and simultaneously the temperature brought to red-glow heat and kept at the same, the smooth platinum causes the ammonia to be burnt to nitric acid, the second reaction which produces free nitrogen being practically unnoticeable.

"The finely divided platinum on the other hand accelerates both reactions, the second one more than the first. By moderate use of the finely divided platinum (platinum black or platinum sponge) with the smooth platinum the operation can be so performed that the reaction takes place rapidly but without any great formation of free nitrogen.

"The form of catalyser to comply with these conditions may vary. If platinum is employed generally a length of one to two centimeters of platinum, over which the gas mixture streams with a velocity of one to five meters per second, is found to be sufficient; when the flow velocity is less, a shorter layer of platinum may be used."

In Patent No. 8,300 of 1902, Dr. Ostwald says:

"The mixture of ammonia and oxygen (air) should contain a large amount of oxygen with reference to the quantity of ammonia, it being necessary that a quantity of oxygen should be present corresponding at least to that represented by the following equation:



"It is, however, advisable to use a larger quantity of oxygen, preferably in the form of air. A further condition for obtaining a practical result is that the temperature employed in the process should exceed 300 deg. C. It is preferable to maintain the temperature between dark and bright red heat. A further condition is that the products of the reaction should be exposed for as short a time as possible to the reaction, as otherwise rapid decomposition of the products would result. For this reason I employ catalysers as short as possible and cause the gases to pass over them at a high velocity. I have found it advisable to so arrange the length of the catalysers and the velocity of the gases in such a manner that the contact of the latter with the former should not exceed one-hundredth of a second.

"As the velocity of the gases should be as high as possible, and also the temperature suitable for the oxidation should be maintained, it is necessary to maintain the velocity of the gases constant. This shows, however, practical difficulties. By a reduction of the velocity of the gases the catalysers would have a low temperature, as the heat of reaction developed in a unity of time would be smaller. By raising the velocity of the gases excessive heating of the catalysers would be caused. For the purpose of avoiding the aforesaid difficulties, I heat the gases to be treated by means of the hot products of the reaction before they come into contact with the catalysers."

The plant required to carry out this process on a commercial scale in connection with a source of ammonia consists of three parts: (1) Apparatus for producing ammonia gas. (2) Apparatus for the actual reaction, or catalysers. (3) Condensing plant.

Fig. 1 shows a general plan of such a plant and indicates the relative space occupied by the various parts. It is adapted to

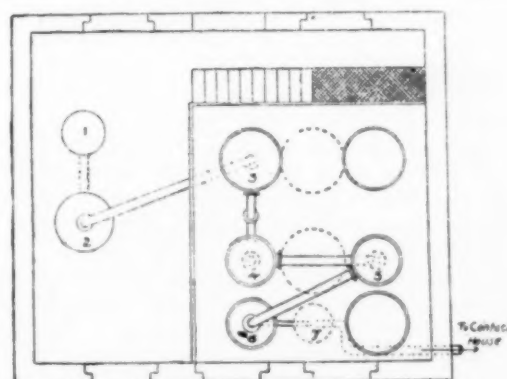


FIG. 2—PLAN OF AMMONIA HOUSE

the use of ammonia liquor. In the case of using cyanamide small modifications in the ammonia plant would be necessary. The ammonia plant takes in crude gas liquor and sends out nearly pure, dry ammonia gas, freed from carbon dioxide and hydrogen sulphide. The gas is not freed from traces of organic materials which may come over with it, for these impurities have been shown to exert no harmful influence on the process.

The ammonia plant for using gas liquor is a standard one, similar to those in use generally. This apparatus is indicated in

Fig. 2. The crude gas liquor is received in the heating apparatus numbered 1 and 2, and to assist in driving out the ammonia gas, heat and a current of air are both used. The gas so drawn off is purified in 3, 4, 5 and 6, by washing and treating with milk of lime. The current of air is supplied by a small compressor.

The air so supplied furnishes a portion of the oxygen necessary for the reaction, and its amount is regulated by automatic differential manometer and regulating valve. The rate

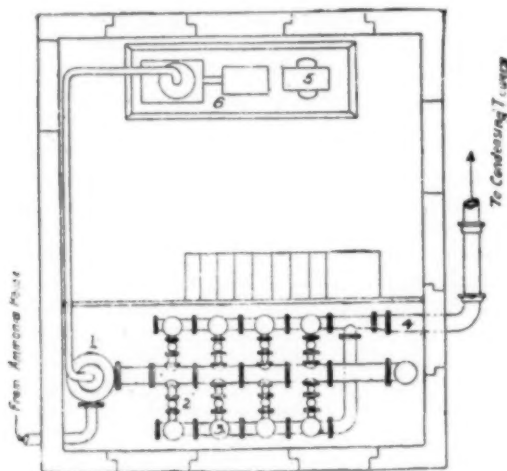


FIG. 3—PLAN OF CONTACT HOUSE

at which the crude gas liquor and the steam are supplied is regulated by hand. The production of ammonia gas by the above apparatus must be perfectly continuous to be efficient.

Mixed with a small amount of air the ammonia gas then passes into the contact house or catalyser house. Here it is mixed with more air, supplied with a fan, and the mixture is regulated by the automatic differential manometer and regulator 1 of Fig. 3. The gas mixture then passes through the platinum contacts 3, by way of the cocks 2, so arranged that any contact can be cut out of service without disturbing the rest. Here the real reaction takes place. Up to this point only ammonia gas and air have been present, and either cast or wrought-iron piping can be used with perfect safety. In the reaction apparatus itself nitric acid vapors, at a high temperature are to be handled. As soon as liquid nitric acid begins to form, stoneware is the only available material.

The hot gases leave the reaction plant through the pipe 4 and pass to the condensing plant, which is shown in Fig. 4. The gases pass into the condensing towers at 1 and meet with a large cooling surface, which is wet by nitric acid trickling continually through the stone filling of the tower. Water is not used because as strong an acid as possible is desired and enough water passes along as the result of the reaction itself.

The condensation serves a double purpose. The nitric acid formed during the reaction, and the water formed, are condensed together to liquid nitric acid. Beside this, any other of the higher oxides of nitrogen which may have been produced are given time to oxidize further, to meet with water and to change to nitric acid. The nitric acid which has been allowed to flow down through the towers is, therefore, used over and over again, becoming stronger in the process. This acid is cooled in the cooling apparatus 3, before sending it back to the tower, and stored in the storage tanks 4 during the interim.

From 4 it flows into the pressure apparatus 5, and from here it is forced by air pressure back to the top of the tower. Three coolers and one storage tank are used in supplying cooled acid to each tower.

The plant shown in Fig. 1 has five towers, each about 60 ft. high, and all acid is transported through stoneware. Whenever acid is to be lifted this is accomplished by air pressure.

From the opening of the last tower there escape nitrogen, oxygen, and a small amount of uncondensed acid, which can be further treated if desired.

It will be noticed that the condensing plant is an important part of the process. The gases from the reaction chamber pass through the five towers, one after the other, and this large condensing surface is necessary to prevent loss. The acid is tapped off at the foot of the second tower, and here it has a density of about 36° Be. It is a pure, not very strong, commercial grade of nitric acid.

Ammonia is the only raw material used in large quantity. A small amount of lime is also needed in the driving off and purifying of the ammonia gas. The product, nitric acid (36° Be.), is a current market chemical. The demand for this strength is, however, not very great, and a more concentrated acid, such as is used for making explosives, is more in request. The average price of ammonia in crude gas liquor, taken all over England, is not far from 10 cents per lb.

Estimate of Profits

The following is an estimate of the profits of a plant for the production of nitric acid from ammonia from the Ostwald process. As a basis it is assumed that each catalyser produces 200 kilograms of nitric acid (36° Be.) in 24 hours, and a plant will be taken employing monthly 25 tons of nitrogen (N) equivalent to 830 kilograms of ammonia (NH₃) per day—to produce nitric acid.

These 25 tons of nitrogen, or about 115 tons of sulphate of ammonia, can easily be obtained from 64 by-product coke ovens. In a gas works we must consider for this purpose a production of about 120,000 cubic meters (4,237,990 cubic feet) in 24 hours.

Out of these 25 tons of nitrogen per month—which corresponds with 83 cubic meters of 1 per cent ammoniacal liquor in 24 hours—we should be able to get, by means of the Ostwald process (taking as a basis a yield of only 85 per cent), the following quantities of different concentrations of acid:—Absolute nitric acid 78.7 tons per month; 93 per cent acid, or 48 deg. Be., 85.6 tons per month; 53 per cent acid, or 36° Be., 148.4

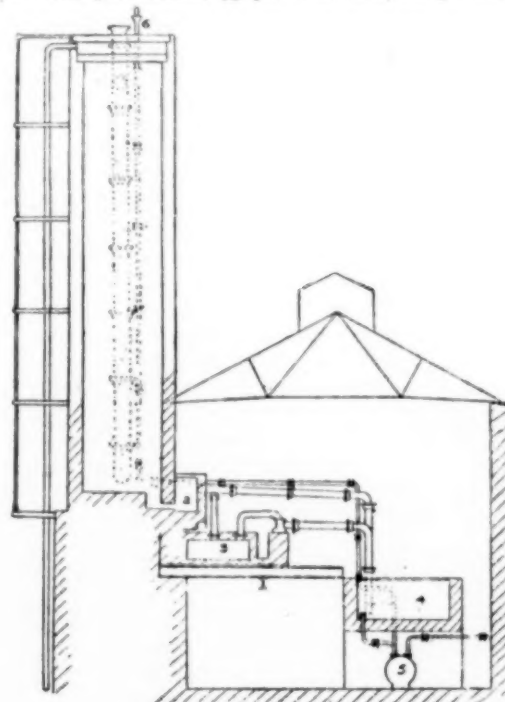


FIG. 4—CONDENSING PLANT

tons per month. The last named product is produced directly by the process; the 93 per cent acid is obtained from the 53 per cent acid by concentration; the "absolute" acid is not steady at all.

For the manufacture of nitrate of ammonia this quantity of nitric acid—say 148.4 tons of 53 per cent—can be used by adding, say, 21 tons of ammonia per month; therefore, from a total quantity of 46 tons of ammonia per month we should

get 99 tons of nitrate of ammonia (allowing 2% as waste) as monthly yield.

The cost of a plant producing 148.4 tons of 53 per cent acid per month by means of the conversion of 25 tons of ammoniacal nitrogen into 53 per cent nitric acid is estimated as follows:

Plant for generating ammonia from gas liquor..	\$7,500
Plant for conversion (catalysers)	5,000
Condensing plant	17,500
Foundations for towers and iron work.....	5,000
Acid storage tanks	750
Air compressor and motor.....	3,000
Platinum (initial expense).....	2,500
Buildings and foundations.....	10,000
Unforeseen outlays.....	3,750
Total.....	\$55,000

Running Expenses

(1) *Steam*.—The same quantity will be required as that to volatilize ammonia out of diluted liquor for other purposes—for instance, for the manufacture of sulphate of ammonia—that is, 20 to 25 kilograms of steam per 100 kilograms of 1 per cent ammonia liquor. As 83 cubic meters of ammonia liquor are used in 24 hours, 20,000 kilograms of steam may be allowed. Taking 100 kilograms of coal at the rate of 46 cents there would be a daily cost of \$12.50, or monthly, say, \$337.50.

(2) *Cooling water*.—A consumption of 200 cu. meters per day may be allowed; this, estimated at something more than a farthing per cubic meter, amounts to \$1.50 per day, or \$45 per month.

(3) *Power*.—To lift the liquid in the condensing house, and for direct air pressure, 12 to 15 h. p. are required and for the running of a fan a further 5 h. p.—that is, 20 h. p. altogether. This means per month 14,400 h. p. hours, and at the rate of 3 cents this amounts to about \$437.50.

(4) *Lime*.—In employing a carbonic acid absorber, the consumption is something more than 1 kilogram of lime (CaO) per kilogram of ammonia (NH₃). In consequence, something like 30 tons of lime are used per month. Figuring the ton at \$3.75 this represents \$112.50.

(5) *Platinum*.—For the whole plant 30 contact elements are required, having a weight of 50 grams, which for a daily production of somewhat more than 100 kilograms of nitric acid corresponds with 200 kilograms of 53 per cent acid per contact element. The wear and tear is not very considerable; it may be estimated at 1.5 grams per day or 45 grams in the month. The contact elements may be used for a month or six weeks, after which time they ought to be scrapped as old metal and replaced. For this exchange it is only necessary to estimate the difference in price between the old and the new metal, which represents about 6 cents per gram. Assuming a monthly exchange, the outlay for all the contact elements requires about \$95. The total expense for platinum amounts to \$140 per month.

(6) *Wages*.—For superintending and reversing of valves and cocks two men are sufficient per shift; for cleaning, a third man is required—altogether six men per 24 hours. Superintendence should not absorb more than \$100 per month.

The cost of manufacture per month, including repairs and superintendence, would comprise accordingly:—

Steam	\$337.50
Cooling water	45.00
Power	437.50
Lime	112.50
Platinum	140.00
Wages	202.50
Repairs	125.00
Superintendence	100.00
Interest and depreciation (15% on \$55,000)	
per month	687.50

Total.....\$2,187.50

The cost of ammonia in the form of dilute gas liquor is

calculated at the rate of \$17.50 per 100 kilograms. The total quantity required amounts to \$4,375 for the 25 tons needed for this size plant. The yield represents 148.4 tons of 53 per cent nitric acid. Reckoning the 100 kilos at \$6, the receipts amount to \$8,902.50.

From these figures it would seem that the operation of a plant for converting monthly 25 tons of ammoniacal nitrogen from the ordinary liquor of gas works, etc., into 53 per cent nitric acid gives the following results:

	Total per month	Per 100 kilos of 53% acid
25 tons of ammonia.....	\$4,375.00	\$2.95
Cost of conversion.....	2,187.50	1.46
Cost of production.....	\$6,562.50	\$4.41
Sales of 14,840 kilograms of nitric acid at \$6.	8,902.50	6.00
Net profit per month.....	\$2,340.00	\$1.59

The above figures of estimated cost, reproduced from the (London) Iron and Coal Trades Review, are of course, based on British conditions. For American conditions various of the figures would have to be changed. The figures are given here as they may serve as a basis of a modified calculation.

The Manufacture of Ammonium Nitrate

Ammonium nitrate is a valuable chemical and there is a large demand for it for safety explosives of all kinds. The market price is fixed by the value of ammonia and that of Chile saltpetre.

The Ostwald process is remarkably well adapted to the manufacture of ammonium nitrate. The nitrate acid is neutralized with a further supply of ammonia, and the solution of ammonium nitrate so obtained is evaporated until crystallization occurs. The neutralization is carried out in wooden tanks and the liquid is then evaporated in vacuum pans almost to dryness. Pure ammonium nitrate separates, and this is dried in centrifugals and packed for shipment. The impure salt left in the mother liquid is dried out and sold as second grade.

There must also be erected a plant to obtain pure ammonia out of the diluted liquor, and an installation for the production of the solid salt. For this purpose different combinations are possible, according to the mode of working, viz., to get the nitrate of ammonia direct from the gas or from diluted liquors and again either refining the salt produced before or after its formation.

In consequence the cost of an installation will vary between \$25,000 and \$35,000—buildings included. This for a production of 99 tons of nitrate of ammonia per month, and in which case we have to use altogether 46 tons of ammonia; out of which—as stated above—25 tons are for nitric acid, and the remaining 21 tons for pure ammonia.

Taking the price of nitrate for explosives at \$17 per 100 kilograms, and reckoning for the purification of 21,000 kilograms of ammonia \$1.050 and further for the preparing of 99 tons of salt another \$990 as wages, etc., the profits of this plant are established as follows, (the figures again referring to conditions in Great Britain):

	Total per month	Per 100 kilo- grams of salt
Value of ammonia, 46,000 kilograms at 17.5 cents.....	\$8,050.00	\$8.13
Of which 25,000 kilograms converted into acid—wages and depreciation	2,187.50	2.21
Purification of the remaining 21,000 kilograms of ammonia.....	1,050.00	1.07
Wages for manufacture of salt.....	990.00	1.00
Cost of production for 99 tons of nitrate of ammonia.....	\$12,277.50	\$12.41
Receipts from 99,000 kilos at 8½%...	16,830.00	17.00
Net profit per month.....	\$4,552.50	\$4.59

It may be estimated that the normal production of nitric acid in the United Kingdom is approximately 25,000 tons per annum, reckoning the acid as being 80 Tw. In ordinary years the amount used up on the spot will be about 20,000 tons, rising to 30,000 tons when the explosives trade is brisk. The miscellaneous trade will account for 5000 to 7500 tons according to requirements.

Action of the Salts in Alkali Water and Sea Water on Cements

An extended investigation on the subject is described in Technological Paper No. 12 of the Bureau of Standards, Washington, D. C., the authors being P. H. Bates, Chemist; A. J. Phillips, Assistant Chemist; and Rudolph J. Wig, Associate Engineer Physicist of the Bureau of Standards. The bulletin comprises 158 pages with many tables and diagrams and only a summary of the object of the investigation and the results can be given here.

The disintegration of cement structures, when placed in contact with sea water, is a phenomenon, which has attracted the attention of cement manufacturers and cement users almost from the first time that such material was used for marine construction. There are cement structures which have withstood the action of sea water for years and probably will continue to do so, yet there are structures which have failed; and it is also possible in the laboratory by artificial solutions to destroy almost completely a briquet, or cube, or cylinder made of cement mortars or concrete.

The cause of this disintegration is not certain, though it is almost universally believed that it is the reaction of sulphate of magnesia of the sea water with the lime and the cement (formed during the setting) and the alumina of the aluminates of the cement, resulting in the formation of hydrated magnesia and calcium sulpho-aluminates, which crystallizes with a large number of molecules of water.

The other constituents both of the sea water and the cement are usually considered of little effect, though lately attention is being drawn to the fact that both sodium chloride and magnesium chloride rapidly attack the silicates.

Concrete structures have been made (especially in this country) which are resisting the attack of sea water to a marked degree. It is, therefore, not surprising that many engineers attribute the disintegration when it does occur to poor workmanship or materials, or to the abrasion of the sand or floating bodies in the water, and to the mechanical action of waves and frost action (as the disintegration usually takes place at or near the water line) rather than to any chemical reaction or crystallization due to such reaction.

The investigation of Messrs. Bates, Phillips and Wig were planned for the purpose of determining the suitability and permanency of various cements in structures exposed to the chemical and mechanical action of sea water and alkali salts and, if possible, the cause of failure or disintegration of cements and concretes.

The study of the subject was begun in such a manner as to determine, if possible, just what reaction would take place when the salts, commonly present in sea water and alkaline soils, were allowed to act on cement and cement mortars. In order that this study should be complete, information should be obtained not only as to what salts present in any solution might cause destruction, but also in what manner this destruction is being accomplished.

Both chemical and physical investigations were made in the laboratory, and field tests in sea water were made at Atlantic City, N. J. In both series of laboratory tests there have been used at various times, in addition to sea water from Atlantic City, solutions of sodium chloride, sodium sulphate, sodium carbonate, magnesium chloride, magnesium sulphate, ferrous sulphate, and also solutions in which there were present in equal parts by weight two salts as sodium chloride-sodium sulphate, sodium chloride-magnesium chloride, sodium chloride-magnesium sulphate, sodium sulphate-magnesium sulphate, so-

dium chloride-sodium carbonate, sodium chloride-calcium chloride, sodium sulphate-sodium carbonate, magnesium chloride-magnesium sulphate.

It will be noted that a solution of calcium sulphate was not used. This salt is comparatively insoluble, and a series of tests using it, even in a saturated solution, would hardly be comparable with the series in which the above were used and in which the solutions contained but 2 per cent by weight of the anhydride salts. Moreover, when this solution contained the sulphuric anhydride radical, calcium sulphate would be formed in the cement.

The conclusions of the authors are limited by the scope of the investigation and since the physical tests reported cover a period of exposure not exceeding 3½ years the conclusions should be considered, as the authors point out, as somewhat tentative. They are as follows:

1. Portland cement mortar or concrete, if porous, can be disintegrated by the mechanical forces exerted by the crystallization of almost any salt in its pores, if a sufficient amount of it is permitted to accumulate and a rapid formation of crystals is brought about by drying; and as larger crystals are formed by slow crystallization, there would be obtained the same results on a larger scale, but in greater time if slow drying were had. Porous stone, brick, and other structural materials are disintegrated in the same manner. Therefore in alkali regions where a concentration of salts is possible, a dense non-porous surface is essential.

2. While in the laboratory a hydraulic cement is readily decomposed if intimately exposed to the chemical action of various sulphate and chloride solutions, field inspection indicates that in service these reactions are much retarded if not entirely suspended in most cases, due probably to the carbonization of the lime of the cement near the surface or the formation of an impervious skin or protective coating by saline deposits.

3. Properly made Portland cement concrete, when totally immersed, is apparently not subject to decomposition by the chemical action of sea water.

4. While these tests indicated that Portland-cement concrete exposed between tides resisted chemical decomposition as satisfactorily as the totally immersed concrete, it is felt that actual service conditions were not reproduced, and therefore further investigation is desirable.¹

5. It is not yet possible to state whether the resistance of cements to chemical disintegration by sea water is due to the superficial formation of an impervious skin or coating, which is subsequently assisted by the deposition of shells and moss forming a protective coating, or by the chemical reaction of the sea salts with the cement forming a more stable compound without disintegration of the concrete, or by a combination of both of these phenomena.

6. Marine construction, in so far as the concrete placed below the surface of the water is concerned, would appear to be a problem of method rather than materials, as the concrete sets and permanently hardens as satisfactorily in sea water as in fresh water or in the atmosphere, if it can be placed in the forms without undue exposure to the sea water while being deposited.

7. Natural, slag, and other special cements tested in concrete mixtures showed normal increase in strength with age both in sea water and in fresh water.

8. In the form of neat briquettes most of the Portland cements of high iron cement, several of the cements of high or normal alumina content and one special slag cement did not show any marked difference in tensile strength whether ex-

¹In service the concrete extends from the sea bottom to a point above high tide, where the wall or pile would always be exposed to the atmosphere. With this condition the sea water could be drawn up the wall by capillarity, the moisture evaporating and leaving the salts, which would become concentrated, and thus possibly cause disintegration especially if mixture is porous. An additional series of tests is now being made in which short piles, 7 feet in length are being placed in sea water so that 2 feet of the center portion will be exposed to the atmosphere. After various periods of exposure the piles will be sawed and the various sections tested for elastic properties and compressive strength.

posed to fresh or sea water for all periods up to two years. Other cements of various compositions showed signs of disintegration after a few weeks.

9. All cements resisted disintegration in sea water better in mortar mixtures than in the form of neat briquettes. In most cases the mortar briquettes had normal strength up to 2 years' exposure.

10. The physical qualities of the cement, which depend essentially upon the method of manufacture, would seem to determine its resistance to decomposition when brought into intimate contact with the sulphate and chloride solutions.

11. Contrary to the opinion of many, there is no apparent relation between the chemical composition of a cement and the rapidity with which it reacts with sea water when brought into intimate contact.

12. Tri-calcium-sulpho-aluminate could not be formed, and therefore disintegration could not result from this cause.

13. In the presence of sea water or similar sulphate-chloride solutions:

a. The most soluble element of the cement is the lime. If the lime of the cement is carbonated it is perfectly insoluble.

b. The quantity of alumina, iron, or silica present in the cement does not affect its solubility.

c. The magnesia present in the cement is practically inert.

d. The quantity of SO_3 present in the cement up to 1.75 per cent does not affect its solubility, but a variation in the quantity present may affect its stability by affecting its rate of hardening.

14. The change which takes place in sea water when brought into intimate contact with the cement is as follows:

a. The magnesia is precipitated from the sea water in direct proportion to the solubility of the lime of the cement.

b. The sulphates are the most active constituents of the sea water and are taken up by the cement. Their action is accelerated in the presence of chlorides. No definite sulphate compound was established.

c. The quantity of chlorine and sodium taken up by the cement is so small that no statement can be made as to the existence of any definite chloride or sodium compound formed with the cement.

15. The SO_3 added to a cement in the plaster to regulate the time of set is chemically fixed so that it will not go into solution when the cement is brought into intimate contact with distilled water.

16. Metal reinforcement is not subject to corrosion if embedded to a depth of 2 in. or more from the surface of well-made concrete.

The production of secondary metals in the United States is shown in the following table, compiled by the Geological Survey:

Metal	1912	
	Short Tons	Value
Secondary copper, including that in alloys other than brass	66,441	\$21,593,325
Remelted brass	101,523	27,279,516
Secondary lead	30,266	6,045,120
Recovered lead in alloys	36,902	
Secondary spelter	52,251	7,750,494
Recovered zinc in alloys other than brass	3,912	
Secondary tin	8,333	14,301,368
Recovered tin in alloys	7,068	
Secondary antimony	13	426,020
Recovered antimony in alloys	2,493	
Total value		\$77,395,843

A crisis in the German potash industry is reported, due to over-production. It appears that the funded securities of the leading companies of the Potash Syndicate, which have been selling at high premiums, have fallen below par, and a number of newly established companies have become insolvent. The law passed two years ago for putting an end to the concessions granted by certain companies to American importers accomplished its object, but has failed to limit the production of potash. A consular report states that it will take several years to equalize the supply and demand of potash, and that legislation is now in progress to regulate in future the production of potash.

Efficiency in Chemical Industries

Presidential Address Delivered Before the American Institute of Chemical Engineers

By T. B. Wagner

During the eighth International Congress of Applied Chemistry, held in New York in 1912, a number of general lectures were delivered, among them one by Dr. Carl Duisberg of Germany, entitled "The Latest Achievements and Problems of the Chemical Industry." With others, I was profoundly impressed with this recital of achievements—a splendid record, indeed, of the distinguished services rendered by the chemist and the chemical engineer. It is but fair that we give the latter full credit, for while the "pure" chemist takes the initiative by developing ingenious theories and syntheses, it is the chemical engineer who follows up the former's work and transform it into commercial success, by which the value to mankind of scientific effort and accomplishments is judged. Dr. Duisberg's essay surely brought to many of us the thrill of romance, but below it all lay a deeper meaning, for it spelled the "triumph of efficiency."

Would not one have to be void of all sentiment not to be stirred when learning of such work, and not to take pride in being a member of so useful and illustrious a profession as that of chemists and chemical engineers? We need not go abroad, however, to learn of the magnificent results accomplished by them, for we have abundant evidence in this country of the marvelous changes which their efficiency has brought about, with the result that this country occupies today a commanding position among nations in the field of applied chemistry.

"Efficiency in Chemical Industries," the subject which I have chosen for this occasion, leads one, as you have seen, into such vast fields of accomplishment and possibilities that I fear my fate tonight might be that of the parson who arose before his congregation and said: "My dear brethren, I shall divide my sermon this morning into three parts—firstly, I shall announce my text; secondly, I shall depart from it, and thirdly, I shall never get back to it."

To avoid such a calamity, the calamity of going astray, I shall speak today only on what efficiency has done for the industry with which I am identified—that of corn products. I trust I have walked in the highways and by ways of that particular domain long enough not to get lost.

A further reason why I have elected to speak on this subject is that experience tells me that we rather welcome an account of accomplishments in industries other than our own, for the precedent of another's difficulties encountered and overcome acts like a tonic to cheer us over the stumbling blocks in our own paths, but they are only stumbling blocks after we have passed them and left them well behind; when they loom before us, they seem to have the proportions of mountains.

The manufacture of corn products in this country is not an infant industry, and much has been written about it, its history and evolution. The first product manufactured from corn was starch, and the first manufacturer was Thomas Kingsford, his plant being located at Oswego, N. Y.

He commenced operations about 70 years ago, at a time when the raw material—Indian corn—was a low-priced commercial commodity, for in those years the population of this country was much smaller than today, home consumption was limited correspondingly, and a demand had not, as yet, been developed abroad. The raw material was cheap and the price of the finished product was high.

The margin of profit, therefore, was considerable, and an attempt at efficiency did not appear imperative, particularly not since competitors were "few and far between," and thus the principal stimulus for efficiency was lacking. The almost exclusive aim—a commendable one—was to produce starch of the highest quality. The matter of yield and of cost was of secondary consideration.

With good quality and rather handsome profits, why talk about economy or efficiency in the boiler house, in the engine room, in the transmission of power, or with respect to labor?—for labor too was cheap in those days and labor unions were unknown.

If the efficiency were to have been gauged, as it should, among other things, by the recovery of products from a given unit, that is to say, by the yield, it cannot be denied that a manufacturer could have taken but little pride in revealing his degree of efficiency.

This should not be taken as a reflection upon the industry at that time, for, to be fair, we must not judge conditions retrospectively. It was the status of the industry in those days, but that the future had many and far-reaching changes in store soon became evident.

The price of corn gradually rose, and, due to growing competition, the price of the finished product declined, narrowing the margin of profit. The manufacturer, therefore, had to begin to pay attention to the subject of yield and to an increase of revenue possibly by recovering some of those products which were allowed to run to waste.

First among these were the nitrogenous ingredients of corn, the so-called "gluten," but the method of recovery was very crude. It was collected while in a wet condition and its sale was in the nature of a local business, that is to say, it was sold to the farmers located in the neighborhood of the factory, and used by them in feeding cattle.

It was not known as a commercial commodity, yet the proceeds from its sale added materially to the reduction in the cost of starch. With an increased output, the local markets eventually proved too small, and it became necessary to recover the gluten in a condition which would permit of shipping it to distant points.

This led to the drying of the gluten, and while the recovery of this product in itself was a step in the direction of efficiency, the methods and appliances resorted to in drying were primitive. It did not take long, however, for efficiency to make its entrance; the apparatus first in use was capable of evaporating about 1000 pounds of water per hour; each unit of the apparatus employed today has an efficiency, expressed in terms of evaporation, equivalent to 9000 pounds of water per hour. The amount of dry gluten recovered in one of our large factories is 250,000 pounds per day.

The hull of the corn, the so-called "bran," underwent the same transformation, and was changed from a waste product, or offal, to a valuable staple product, the amount recovered per bushel being approximately the same as that of the gluten.

In the course of time, the manufacture of glucose was started, and the enterprise flourished. The introduction of this new product from corn furnished a splendid opportunity for the display of efficiency.

In a measure, the industry was an imported one, for glucose had been made from potatoes in Germany many years prior to the establishment of the first factory in this country.

In those early days it was necessary not only to import the machinery, but skilled labor as well. Among the most important were the men in charge of the vacuum pans. They were brought here at the expense of the manufacturer and engaged at extravagant salaries. They were quick to realize their advantage and soon became the "bosses" of the plant. They ruled absolutely. Their work was surrounded with great mystery, but it had to give way to efficiency, and today the position of a pan man is no more important than that of any other workman, in fact, unskilled men are selected for this work and soon become experts at their posts.

The problems which arose in the manufacture of glucose taxed the ingenuity and efficiency of the chemical engineer. To illustrate, I will cite the history of the Chicago Sugar Refining Company, which was organized by Chicago business men with a paid-in capital of \$1,250,000, a large amount of money even in present-day enterprises, but particularly so in 1880, when this factory was constructed.

Its purpose was the manufacture of anhydrous grape sugar

(pure dextrose), the production of which, on a commercial scale, had been made possible by Dr. Arno Behr. His method differed from all previous ones in that alcohol was not required in the process of crystallization.

The price of sugar was high in those days; I believe it sold at 8 cents a pound. Anhydrous dextrose, or grape sugar as it was called then, could be manufactured quite cheaply, as corn was still sold at a relatively low price.

The scheme was to blend the soft cane sugar from Louisiana with this anhydrous dextrose, and sell the product to the confectioners, for whose purposes it was suited most admirably. The factory started off a great success. The product turned out was of the highest purity and called forth the commendation of every one who tried it.

Thousands of barrels were sent out in the course of a few months, but in the course of another few months the shipments commenced to be returned to the factory, because it was found that the anhydrous sugar had absorbed the moisture contained in the soft sugars, with the result that the contents of the barrels had solidified into a hard mass.

It was impossible for the confectioner to use this product, and the company stood face to face with the failure of an enterprise into which, by this time, approximately \$1,500,000 had been invested. There was no alternative but to shut down the factory. The question now arose what to do next.

Many suggestions were submitted, among them very worthy ones, but they were discarded until the chemical engineer stepped into the breach and suggested that this anhydrous sugar plant be converted into a glucose factory. I shall not go into details, but simply recite the fact that after untold efforts and untold moments of anxiety, the new venture succeeded, and in the course of time it prospered. It may be properly said that it was principally responsible for the development of the American industry of corn products, as we know it to-day.

Even though it prospered, there were many problems. Every step in the manufacture of glucose requires the most careful attention, and chemical control is needed incessantly. The aim is first to obtain the raw material—starch—in as nearly chemically pure a state as possible; this means the elimination of all nitrogenous and fatty matter, a task which offers the greatest difficulties, because of the enormous scale on which the business is conducted, because of the condition of the raw material—whether fully matured or not, whether entirely sound or slightly deficient, even because of atmospheric conditions, which exercise a certain influence.

The ambition of the manufacturer is to produce water-white, crystal-clear glucose, which will retain its color in all seasons, in all climates and even if kept in transit or storage for a long period of time. Such quality depends upon a thousand and one factors, some of which it is very difficult to control. The refining of the glucose and the treatment of the refining agents are important problems, which, however, have been worked out most successfully as the result of applied efficiency on the part of the chemical engineer.

The recovery of the gluten and the bran was an important step forward, but one of the most valuable parts of the corn was still allowed to go to waste, viz., the germ, which yields the oil. There was no incentive to recover it, since no one seemed to want the oil. Had it been produced on a large scale, there would not have been a market for it, although it was realized, even in those early days, that a vegetable oil of the character of that obtained from corn must eventually become a valuable article of commerce; so it did, but it took many years of hard work to bring about this condition.

Shortly before I entered the business, less than 15 years ago, they had just started producing corn oil on a large scale, but had no market for it—the oil went begging; that was a serious condition. The Chicago factory produced at that time about 15,000 pounds of oil per day, and selling, as it did, for less than 15 cents a gallon, the revenue from this production was but \$250. Today the value of a gallon of corn oil is nearly 50 cents, and the amount of oil recovered from the

same number of bushels as in the Chicago factory is worth \$2,700.

This is not due altogether to the increased selling price, but also to the greater efficiency prevailing in the separation of the germ, and the extraction of the oil, resulting in a yield three times larger than in the days of the Chicago factory. Today the gross value of the oil recovered from one bushel of corn, together with that of the oil cake obtained as a by-product, is equivalent to 25% of the purchase price of the corn.

The ingenuity of the chemical engineer did not stop there. The price of glycerine was rising steadily, hence the proposition suggested itself of separating the glycerine from the fatty acids. What this meant is evidenced when I recite that glycerine today sells at 18 cents per pound and corn oil at about 6½ cents, and that 100 pounds of corn oil yield 12 pounds of glycerine; the price of crude oil and fatty acid is substantially the same.

To the list of by-products recovered, gluten, bran, oil cake, oil and derivatives such as glycerine and fatty acids, another was soon to be added. We still had a waste product, which, if recovered, seemed likely to be converted into a revenue producer of the first magnitude.

I am referring to the solids contained in the so-called "steep water," the water in which the corn is immersed and softened prior to grinding. It contains the most valuable ingredients of the grain, viz., the organic phosphorus compounds, magnesium and potash salts, nitrogenous bodies and sugars.

Many efforts have been made to recover these solids in dry form, but, owing to the hygroscopic condition of the residue, such methods were found to be impracticable.

In some localities serious consequences were the result. I have in mind the experience we had at one of our factories located in the State of Iowa, and grinding about 10,000 bushels of corn per day. The steep water was not recovered, but, together with the wash waters from starch and gluten, was run into a creek, which in turn discharged into a river of fair size.

This method of disposing of the steep water soon became a menace to the plant, for proceedings were instituted in the courts with a view to having the factory shut down and declared a public nuisance because the steep water contaminated the river, killing the fish, and contributing in many ways to the discomfort of the residents.

The owner of the factory being unable to satisfactorily dispose of this waste as a last resort constructed a pipe line to a farm located about three miles from the factory and entered into an agreement with the owner of the farm whereby he was permitted to conduct the steep water through the pipe line from the factory to the farm and discharge it there. For that privilege, besides furnishing a most excellent fertilizing material, he had to pay the farmer \$3,000 annually.

Today we recover this former waste by collecting it, concentrating it in vacuo and adding it to the gluten feed in the form of a syrup, with which it is subsequently dried—the feed acting as an absorbent. Instead of investing in pipe lines and paying for dumping rights, the waste of a 10,000 bushel plant was thereby converted into a revenue of almost \$100,000 per year. Applied to the industry as a whole, this former waste furnishes today an annual gross income of approximately \$1,500,000.

Very little is now running to waste. Whatever small loss there is, is caused by the soluble solids carried off in the water used in the washing of starch and gluten. However, these solutions of solubles being very dilute, it is doubtful whether an efficient method will ever be devised for their recovery at a profit. It will be a question of economical evaporation, therefore, largely an engineering problem. Nor will the recovery of these solids add materially to the efficiency record in point of yield.

Efficiency has manifested itself in our industry in many ways. As production increased and finally exceeded the de-

mand ways and means had to be found for diverting the surplus into new channels. This meant partly new products and partly new markets. The latter were secured by entering our starches into competition with products mostly foreign, such as rice, wheat, potato and cassava starch; and by studying closely the needs of the respective industries requiring starchy materials we have succeeded, in a large measure, in replacing rice, etc., with products of corn.

The development of new products occurred simultaneously, and to the series of bulk products were added, in the course of time, a large number of special products, such as thin boiling and modified starches, suitable for every conceivable technical purpose, dextrines and gums, special varieties of glucose, mixed table syrups, so-called "70" and "80" sugars, and refined, hydrogenated and vulcanized corn oils.

There is every prospect of further additions to the present number. Products of corn, in one form or another, are consumed today in almost every industry, and they reach every corner of the civilized world.

Figuratively speaking, this branch of efficiency was raised from 1 to 100—that is to say, where originally the industry was based upon the manufacture of only one product, to wit, corn starch, today the number of separate articles obtained from corn presents the formidable array of 100 products and more.

Hardly anything, however, contributes so much to the general efficiency of an industry as the individual plant capacity. This is the part of our business which requires the special attention and skill of the engineer.

It has been only ten years since we stopped operating plants the unit of which was 500 bushels of corn per day. These plants could not compete with modern conditions for the simple reason that they did not keep pace with the demands of efficiency. How can a plant grinding 500 bushels of corn a day enter into competition with a plant converting into commercial commodities 30,000 bushels or even 50,000 bushels of corn, which is the daily capacity of the latest addition to our chain of factories, viz., the mammoth plant at Argo, Illinois?

It is the concentration of operations that makes it possible for this plant to carry off highest honors in point of efficiency, and this concentration is carried through every department of the plant, each department being organized as a manufacturing unit of its own.

The boiler house is our steam factory. It is the business of the man in charge to manufacture and deliver steam at the lowest possible cost and if you could go through the boiler house you would be surprised, perhaps, to find to what extent a chemical control is observed, and to what extent it contributes towards the low cost of steam.

The efficiency of the boiler house depends, of course, not only upon its operation, but equally as much upon the equipment, and so the old tubular boilers had to give way to modern high-efficiency water tube boilers. Where formerly the standard unit was 100 h.p. it is now 600 h.p. per boiler. We now have only mechanical stokers in place of hand-fired furnaces. Great savings have been brought about in coal and ash-handling machinery, so that the operation of a boiler plant today requires but a fraction of the labor formerly employed.

Coincident with the increased efficiency of the boiler house was the rational, the scientific, use of steam. The evaporation in dryers and vacuum pans is done through exhaust rather than live steam, and one may well point with pride to the fact that in spite of the large amount of exhaust steam produced, our plants are operated without the discharge into the air of a single pound of unused exhaust steam.

The engine room is another such manufacturing unit, and a high degree of efficiency is required to produce and transmit motive power at a low cost. Here the slide valve engines had to yield to the Corliss type, and more latterly to the steam turbine. The costly transmission of power by belts, rope drives and transmission shafts had to give way to elec-

trical power. Efficiency is carried into the minutest detail, even apparently so small an item as lubricating oil did not escape the general policy of efficiency, and while such items do not represent an imposing saving per se, the aggregate foots up a substantial amount.

The milling department is another unit of its own, and so is the refinery, the feed house, the oil plant, the dry starch house, the dextrine department, etc. Each one of these departments is in charge of a chief, responsible for the output, its quality and cost. This general efficiency is carried further in that we operate our own box and carton factories, our printing shops, barrel factories and tin can plants, which latter have a record of efficiency second to none in this country.

You will have noted that we distinguish between two domains of efficiency: first, that of the manufacturing department, and secondly, that of the engineering department. In the latter may be included plant construction, for efficiency does not reign only on the inside, but makes itself felt on the outside as well. Improved plant construction leads to reduction of maintenance charges, to a lowering if not elimination of fire risks, accompanied by a corresponding lowering of insurance rates, to a better safeguarding of the employees, to a reduction of accidents and to an improved sanitary condition. The last named features in turn lead to increased efficiency of the workmen, without which any attempt at a high degree of general efficiency must come to naught.

Another link in the chain of general efficiency is furnished by labor-saving devices, the result of which is that less men are employed today in a factory grinding 30,000 bushels than were formerly required to operate a plant with a capacity of only 10,000 bushels.

Gentlemen, I have singled out the industry of corn products because it furnishes one of the most striking examples of what efficiency has done for the development of a chemical industry within a comparatively brief space of time. Unlike other industries, such as steel, or sugar, our industry is a conglomerate of a number of others. Per se, the manufacture of starch has nothing to do with that of oil; the manufacture of corn syrup nothing with the production of concentrated feeding stuffs; the manufacture of dextrines nothing with that of dextrose, etc., yet these various departments are so related to the whole as to form inseparable parts of it, and the efficiency of the whole depends, therefore, upon the efficiency of each branch.

The net result of our efforts with respect to efficiency is perhaps best illustrated by the fact that we pay today for our raw material—corn—three times as much as our predecessors, and yet we sell our products in the markets of the world at one-third of their price.

To continue and increase this efficiency, it is necessary that we should have young men with the proper training—not only with a scientific schooling, but such as have received a thorough training in engineering, who know the parts and functions of machinery and apparatus, who have a fair knowledge of factory operations, and who have a general understanding of the principles of manufacturing.

It is gratifying to note that the number of colleges and universities is increasing from year to year, where a course of chemical engineering is added to the curriculum of the chemical student.

The chemical industries of this country have grown from a small beginning into a position of great importance. A large share of the credit is due to the schools which furnished the men. They must give us men of ideas, men with initiative, men with mental and physical equipment, to carry through their creations of mind into creations of fact.

No matter how small a cog the individual may be in the big wheel of industry, he may well be proud of his share in the building up and development of the chemical industries which contribute materially toward the prosperity of this country. If his work should go unnoticed by the public at large, he will find comfort in the fact that "the

greatest joy of those who are steeped in work, and who have succeeded in finding new virtues and understanding the relations of things to each other, lies in work itself."

Such work cannot result other than in efficiency; efficiency stands for all that is great and potential. Efficiency is the making of a man, efficiency is the making of an industry, efficiency is the making of a nation.

The Use of Waste Heat Gases in the Paper and Pulp Field

One of the ideas which Philip B. Sadler, of the Swenson Evaporator Company, Chicago, has included in the design of the apparatus of the Chesapeake Pulp & Paper Company, West Point, Va., is the use of waste heat gases from the rotary black ash furnaces to produce the generation of steam in the boiler, and then with this steam to carry out all of the evaporation of the black liquor in the Swenson multiple-effect evaporator. This idea of using waste heat from special furnaces to generate steam in boilers is not new, although it is a decided novelty in the pulp field, the engineers having been slow in the past to adopt this particular means of insuring economy. It has, however, been tried out and found successful.

It is interesting to note that the original source of the heat accomplishing the evaporation in the multiple-effect evaporators is woody organic matter in the black liquor itself. The strong liquor from the evaporator, which has had most of the water driven from it, is burned in the rotary incinerating furnace to an ash. This ash, containing considerable carbon, passes into a so-called melting furnace, operated under an air blast, and from which originate the hot gases to generate steam in the boiler.

By using a quadruple effect evaporator in this way, there is sufficient heat provided by this ash to accomplish the entire evaporation required. This question of multiple-effect evaporation is what makes a success; where Swedish engineers have failed because they attempted the same thing in a single-effect open-pan evaporation, that is, used this direct heat in connection with an open evaporator. In this case there was far from enough heat to produce the required results. It is evident that the type of evaporation is the key to the situation, so far as economy is concerned.

Ton of Coal Makes More Coke Than Formerly

The quantity of coal required to produce a ton of coke is much less than formerly. The average gain in 1912 compared with 10 years ago is probably at least 160 pounds. It is doubtful if in the earlier years the actual yield of coal in coke exceeded 60 per cent, whereas in 1912 it was 67 per cent, according to the United States Geological Survey. This gain is largely due to the increase in the production of by-product coke, in which the yield of coke from a ton of coal is very much higher than in making beehive coke.

In Illinois, Indiana, Massachusetts, Michigan, New Jersey, New York and Wisconsin, where coke is made exclusively in by-product plants, the yield varies from 69.6 per cent (in Wisconsin) to 81.8 per cent (in Indiana), whereas in the States where beehive practice prevails the yield in 1912 varied from 50 per cent (in Georgia) to 66.5 per cent (in Pennsylvania).

Potash Importations.—The importation of "potash salts" for consumption into the United States during 1912 amounted to 622,179,164 pounds, valued at \$10,692,285, according to W. C. Phalen, of the United States Geological Survey. This importation is only a part, however, of the potash salts entering the United States. To it should be added the importation of kainite and "manure salts," including "double manure salts." The imports of potash salts of these classes amounted to nearly 700,000 long tons, valued at more than \$4,000,000. The imports for consumption of materials entering largely into the fertilizing industry, plus the domestic phosphate rock, reached the total valuation of over \$46,000,000.

The Temperature of Certain Operations in the Metallurgy of Copper and Lead

By G. Howell Clevenger

The accurate determination of elevated temperature in industrial operations has only been possible since the development of the Le Chatelier thermo-couple; and as the introduction of this instrument and its various modifications into general use in metallurgical plants has been rather slow, it is not surprising that even at the present time there are very few published temperatures of metallurgical operations.

Many industrial and metallurgical operations involving heat are carried on with wonderful facility by workmen who through long experience have learned to associate cause and effect. These men are often able to successfully control operations, the success of which depends upon temperature limits of but a few degrees; and yet these same men could not tell within several hundred degrees the absolute temperature of the operation which they have performed for years. Their work is, therefore, not, nor can it be for lack of adequate means of expressing it, a part of recorded science, but rather an art, known to but the one man who, when he dies, takes the knowledge of it with him. With proper temperature measurements, the means is at hand for faithfully recording the history of metallurgical operations, in so far as the degree of heat employed is concerned.

Copper Blast Furnaces.—Temperature measurements made upon two furnaces, running side by side, extending over a period of two weeks, gives the average temperature of one as 1201 deg. C. and the other as 1207 deg. C. The slags made by both furnaces were almost identical, i. e., SiO_2 31 per cent., FeO 52 per cent.

The following shows the effect of temperature upon the rate of smelting:

	Furnace No. 1.	Furnace No. 2.
Smelting at a furious rate.....	1261°	1255°
Smelting at a normal rate.....	1197°	1227°
Smelting very slowly (apparently lower limit)	1123°	1137°

Two pyritic furnaces making the same slag gave results as follows:

1. Smelting raw ore..... 1240°
2. Smelting roasted ore..... 1346°

Furnace No. 1 ran slower and the slag was noticeably thicker than No. 2.

With the so-called compromise smelting, determinations at six different plants gave results about the same as those running upon roasted ore. These temperatures were not over 15 deg. upon either side of 1230 deg. Silica appeared to have the principal influence over this range.

All the temperatures, with the exception of the series about to be discussed, were taken with apparatus designed to automatically integrate a mean value for its observation. To discover rapid and small temperature changes of the slag, as it flowed from the furnace, a modification of the Le Chatelier apparatus was used which was almost free from the integrating tendency. With this apparatus several days of continuous record were made of the slag temperatures of a furnace, and

the somewhat surprising fact was established that there is a very distinct change in temperature of the slag at each period of charging.

A portion of such a record is shown in Fig. 1. It will be noted that from charge to charge there is a temperature cycle of about 40 deg. The temperature rises to a maximum about half way between charges.

Copper Reverberatory Furnaces.—A considerable variation of temperature in reverberatory practice is noticeable. A portion of this variation is due to the difference in the ores smelted and the composition of the slags made; but the design of the furnace and careless operation are also important factors.

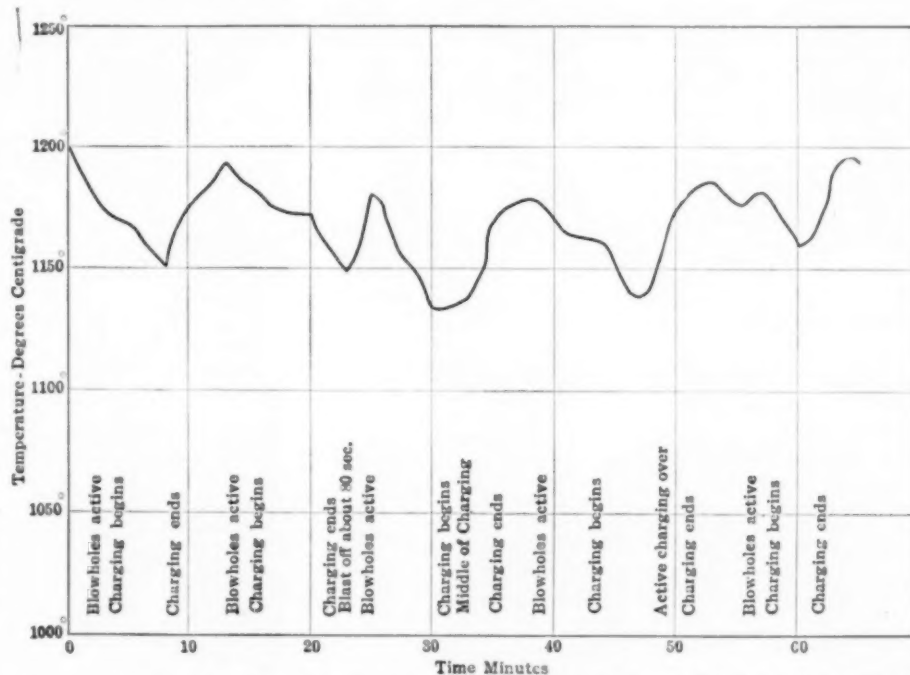


FIG. 1—SHOWING THE VARIATION IN THE TEMPERATURE OF THE SLAG FROM A BLAST FURNACE

Smelting in the blast furnace, being a continuous operation, due to the constant feeding of the charge, the effects of careless operation are more or less minimized; while the reverberatory furnace being operated intermittently, the opportunity to lose considerable heat, through the faulty judgment of the workmen as to just when the furnace should be tapped, is ever present.

All reverberatory furnaces are exceedingly wasteful of heat, largely on account of the necessity of keeping all parts of the furnace at a smelting temperature. In recent years this has been, to certain extent, overcome by the use of the waste gases for generating steam, and in at least one case, by the use of a regenerative furnace, similar to the open-hearth steel furnace.

Ordinarily the extreme variation in the melting point of reverberatory slags is not over 100 deg. C., while in the cases investigated, the temperature of the slags ranged from 40 deg. C. to 350 deg. above the melting point.

In furnaces of poor design, the heat gradient shows a very poor utilization of the calorific value of the fuel. In such a furnace there is a great fall in temperature in passing vertically from the roof of the furnace to the charge.

The accompanying table gives the temperatures at various points along the center line of three furnaces:

	Furnace Number.		
	No. 1.	No. 2.	No. 3.
Charging hole from front 1.	1260° C.	1308° C.	1523° C.
" " " " 2.	1305°	1353°	1594°
" " " " 3.	1346°	1449°	1723°
" " " " 4.	1339°	1540°	1723°
Temperature of slag.....	1202°	1290°	1310°
Melting point of slag.....	1190°	1190°	1285°

Reverberatory Flue.—The temperature was determined at ten points in a flue 6 ft. square and 110 ft. long, which conducted the gases from a reverberatory furnace to a stack, 60 ft. in height.

Temperature of gas at furnace.....	1300° C.
" " " 14 ft. from furnace.....	1217°
" " " 27 " " ".....	1112°
" " " 41 " " ".....	1097°
" " " 54 " " ".....	1045°
" " " 67 " " ".....	911°
" " " 80 " " ".....	807°
" " " 94 " " ".....	767°
" " " 107 " " ".....	727°
" " " 120 " " " (foot of stack).....	642°

The accompanying curve shows the tendency of the temperature of gas to rise when it is forced to descend, as well as the tendency of the temperature to fall when it ascends.

Copper Refining Furnaces.—At the different plants, where temperatures were taken of the refining furnaces, the results agreed closely. The following is average practice:

Charge melted and ready to rabble.....	1141° C.
After 25 minutes rabbling.....	1103°
" " 75 " " ".....	1103°
At end of rabbling.....	1103°
After 20 minutes poling.....	1110°
At end of poling.....	1117°
Heated to.....	1125°
After ladling 20 minutes.....	1121°

Copper Converters.

Matte introduced.....	1170° C.
Turned down to skim.....	1297°
Turned back to blow.....	1284°
Cooling during skimming.....	13°
Temperature of escaping gas at end of 10 minutes....	1260°
" " " " " " 20 ".....	1270°
" " " " " " 30 ".....	1275°
" " " " " " finish.....	1195°

Lead Blast Furnaces.—The temperature of the slag, produced by a lead blast furnace when smelting a given charge, is remarkably constant. The skilled smelter, universally, judges the condition of his furnace by the character of the slag. One of the most important factors is the temperature of the slag. Irregular operation of the furnace is at once shown by a change in the mean temperature of the slag.

The slag from a furnace, running upon a 2/5 slag of the following composition,

Fe = 30.0 per cent
CaO = 12.0 per cent
Al ₂ O ₃ = 8.0 per cent
SiO ₂ = 31.0 per cent
Zn = 10.0 per cent

showed a mean temperature of 1126 deg. C.

The temperature of the slag when using a half slag was 1134 deg. C.

Four furnaces, running nominally upon a 3/5 slag, actually gave the following slags and corresponding temperatures upon two consecutive days. The higher silica content of the slag forced the furnaces off their reduction; but the restoration of the regular slag resulted in a normal furnace. (The table for the second day is given on top of the next column.)

First Day	
Average Slag Analysis	Temperature of Slag
SiO ₂ = 34.0 per cent	Furnace No. 1.....1171° C.
FeO = 30.5 per cent	" " 2.....1159°
MnO = 3.7 per cent	" " 3.....1167°
CaO = 15.0 per cent	" " 4.....1170°
MgO = 1.3 per cent	Average 1170°
Al ₂ O ₃ = 6.4 per cent	
Zn = 5.8 per cent	

The temperature change for small variations in the silica content of lead blast furnace slags appears to be not far from

Second Day

Average Slag Analysis	Temperature of Slag
SiO ₂ = 32.0 per cent	Furnace No. 1.....1145° C.
FeO = 31.0 per cent	" " 2.....1145°
MnO = 3.8 per cent	" " 3.....1156°
CaO = 14.5 per cent	" " 4.....1148°
MgO = 1.3 per cent	Average 1149°
Al ₂ O ₃ = 6.6 per cent	
Zn = 5.8 per cent	

9 deg. C. for each per cent of silica contained in the slag. Upon the above basis a 3/4 slag (which contains 36 per cent of SiO₂) should give a temperature of 1185 deg. C. The mean of ten determinations upon slags of approximately this composition gave a temperature of 1080 deg. C.

Roasting Furnaces

Long Hand Reverberatory.—Temperatures in the hand reverberatory when roasting leady mattes show considerable variation, depending upon the stage of the roast. The following

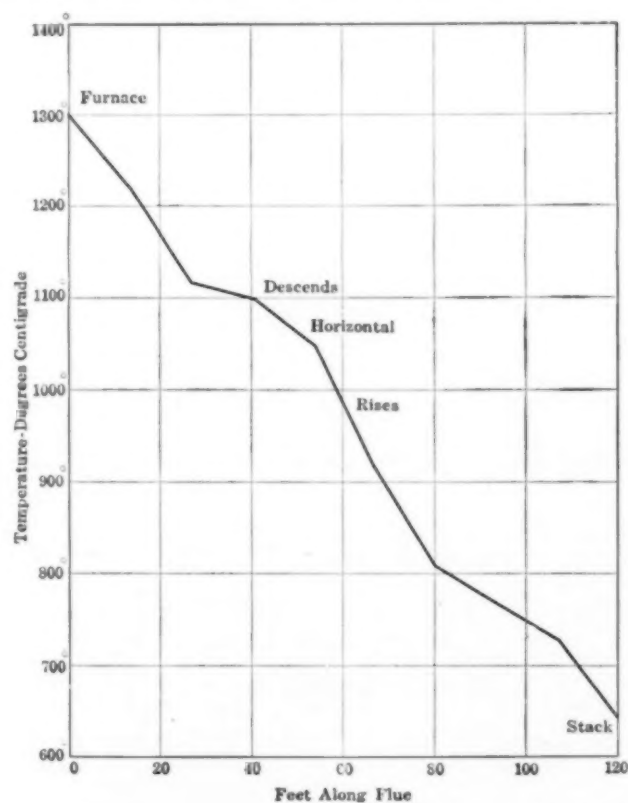


FIG. 2—FLUE CONVEYING GAS FROM A REVERBERATORY SMELTING FURNACE

series of temperatures, illustrated by Fig. 2, were taken in a furnace 58 ft. long, having ten doors on a side. This furnace did not have a fuse box.

The temperatures on side "A" were taken after moving the charge forward and during the highest heat, while those on sides "B" were taken with a low fire as the charge was about to be drawn.

Door No.	Side "A"	Side "B"
1.....	523° C.	487° C.
" " 2.....	575°	612°
" " 3.....	668°	*537°
" " 4.....	702°	737°
" " 5.....	742°	757°
" " 6.....	802°	757°
" " 7.....	876°	857°
" " 8.....	1010°	952°
" " 9.....	1215°	1084°
" " 10.....	1235°	1197°

*Door No. 3 was opened by a workman for the inspection of the charge.

Pearce Turret.—The temperatures at six equidistant points in a single-hearth furnace, roasting heavy sulphide ore, are shown in Fig. 3. In every case the end of the couple was 1 in. above the surface of the ore. The first and last of the three fireplaces were in use.

Herreshoff Furnace.—The temperature of a furnace of this

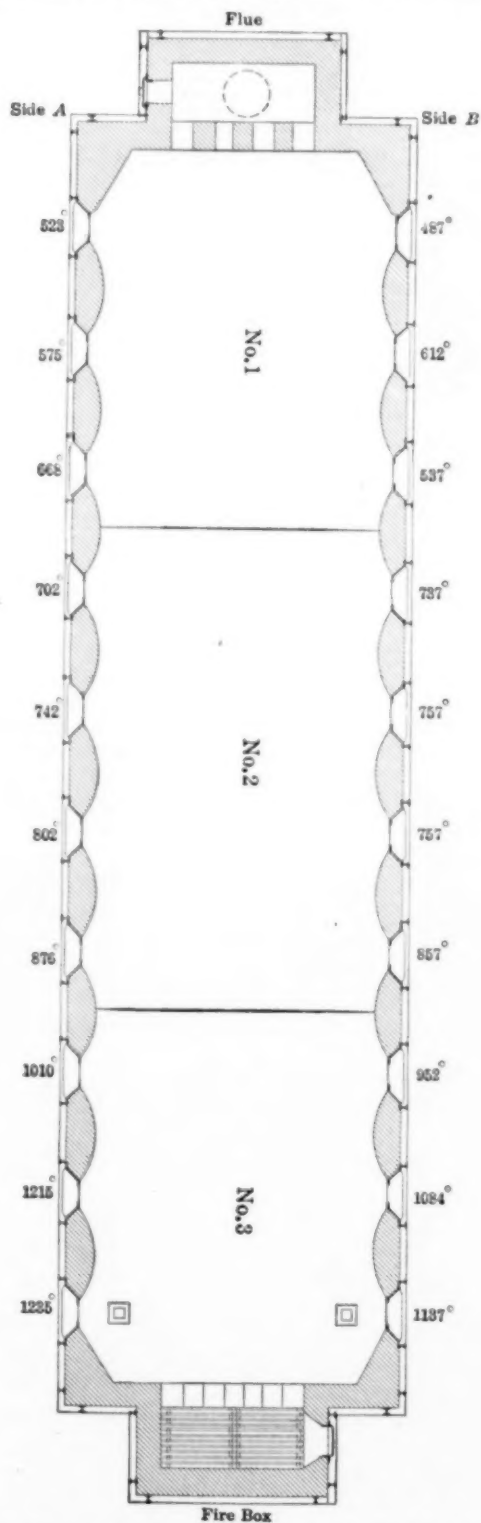


FIG. 3.—LONG HAND REVERBERATORY ROASTING FURNACE

type apparently need not be confined within narrow limits. The upper limit is fixed by the avoidance of sintering and the formation of refractory ferric oxide, while the lower limit is fixed by the necessity of a sufficiently complete expulsion of the sulphur. Temperature readings show that a satisfactory temperature for efficient work and avoidance of ferric oxide

is 590 deg. C. for the third floor and 680 deg. C. for the fourth floor.

I am indebted to Dr. M. N. Bolles for furnishing the data from which this article has been prepared.

Palo Alto, Cal.

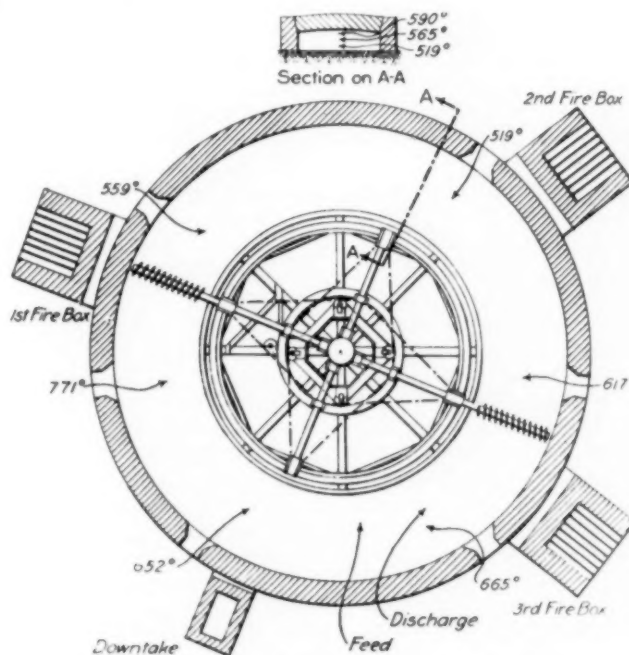


FIG. 4.—PEARCE TURRET ROASTING FURNACE

The metal production of New Mexico in 1912 was valued at \$8,528,000, an increase of \$5,823,000 as compared with the previous year. The important feature of the year's production was the great increase in copper. The principal increase in copper was due to the operations of the Chino Copper Co. The zinc production also showed an increase due to operations around Kelly, where the Tri-Bullion mill produced concentrates by wet dressing and magnetic separation. The Ozark company has recently opened a new mill, employing a flotation process and it is probable that the 1913 production of zinc will show a further increase.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in April, 1913, was sixty-two. The total quantity of ore milled during that period was 2,356,204 tons. There were 10,046 stamps in operation with an average duty of 8.85 tons per twenty-four hours. Tube mills in commission numbered 285. The yield for the month was 784,974 fine oz. gold.

By-product coke ovens have been used in the United States for twenty years, the first having been built at Syracuse, N. Y., in 1893. The original plant consisted of twelve Semet-Solvay ovens, but has since been enlarged to forty ovens. The first ovens of this type had a charging capacity of 4.4 tons of coal and the time required for coking was twenty-four hours. Ovens of the same make to-day have a capacity of 16 tons of coke. Other types of by-product ovens in use in this country are the Otto-Hoffman, the Koppers, the Didier and the Klönne.

The Institution of Mining and Metallurgy, London, has received from Lady Wernher and the co-executors of the will of the late Sir Julius Wernher, the sum of £10,000 as a special endowment fund in memory of Sir Julius. Of this sum, one-half was given by Lady Wernher personally, the remaining half being a bequest. The only condition attaching to the gift is that Lady Wernher desires it to be held intact as an aid in permanently strengthening the institution in which Sir Julius Wernher took a great interest.

The Arizona Copper Company produced during the month of June, 1913, 1500 tons of copper.

Iron and Steel Market

July has seen a curious reversal of sentiment among steel producers, whose views had been chiefly pessimistic, curious in that it is subjective, not due to any discernible change in the mental position or the actions of buyers whose commitments have continued through the month of July at the low rate reached late in June. Normally such changes in sentiment are due either to a change in the flux of business in the industry or to a change in general industrial and money conditions, presaging, by reasoning from the general to the particular, a change in the branch of human activity known as the steel industry. Perhaps this latter suggestion tends to discredit the much quoted dictum that "iron is the barometer of trade," for a barometer is expected to presage changes and if a change in the rate of flow of steel orders presages a change in general industrial conditions, then these general conditions cannot be expected to act as prophet for the steel industry. The facts seem to be that if iron ever was really the barometer of general trade, it was so only to those who could not discern other signs just as trustworthy, though less spectacular, and that steel makers now undertake to see farther ahead than formerly, in which effort they sometimes meet eventual disappointment.

It is the duty of this report to depict, rather than to defend, the state of mind existing in the industry. The facts upon which the improved sentiment among sellers seems to be based are simply that the money strain appears to show signs of relaxing, the crops will soon be out of danger, uncertainties arising from Congress will soon be resolved, and the consumptive powers of the country, even in a time of great reserve among buyers and consumers, have been shown to be large. These facts, however, are also the property of buyers, who have not changed their attitude.

It does not, however, follow that if there is an improvement in the outlook buyers should at once change their policy. They are taking full tonnages of material; they would buy for forward delivery only to protect themselves against loss by prices advancing or by deliveries upon belated purchases proving inadequate. No such dangers confront them. As to prices, when there has been a prolonged advance such as that of 1912, followed by a period of stationary prices, the normal development is a decline, not a fresh advance superimposed upon the previous one. The dip is large or small, depending upon the recuperative power of the mill position through the order books tending to fill instead of to empty further. In the past few months the producers have had to face an eventual readjustment in prices, and merely to conclude that the readjustment will prove small in extent and brief in duration would be sufficient for them to take the more hopeful view of the future which they now seem to hold.

The comparison between productive capacity and the demands of the country, plus the export trade, is unusually favorable. In the past few years capacity has increased at much less rate than demand has normally increased, and in no quarter has any valid argument been made that the rate of increase in demand is destined to undergo a material decrease. It should, therefore, be unusually easy to fill the steel mills to capacity. This, indeed, has been the experience of recent years, for all those who have observed steel market conditions over a period of years have expressed surprise at the prosperity of this industry, compared with business prosperity in general.

The July output of iron and steel has been very large for a July, showing a smaller decrease from May and June than is usually forced by weather conditions alone. Shipments have been readily taken. Nevertheless some mills are rapidly reaching the end of full engagement and must soon receive fresh business at a greater rate or materially curtail production. A peculiar feature of the situation is that there is much diversity in the position of different mills, for some are very well booked for several months of substantially full operation.

Prices of steel products have undergone no material change. The majority of products are firmly held, though the grip can hardly be maintained long without an improvement in actual

bookings. In wire products there is a continuation of the weakness, which may be excused as seasonable. In sheets the market is somewhat softer, and the leading interest has now been forced to take cognizance of the fact by adjusting prices to the market upon current shipments made under contracts at its full prices, below which the open market began to sag months ago, but which did not come into actual operation until about July 1. It does not revise the contracts as a whole, nor is it soliciting fresh contracts at the cut prices.

Pig Iron

The pig iron market as a whole has not developed a definite turn. Southern iron has grown distinctly stronger, but northern iron thus far has not responded fully to the leadership which in all previous movements, whether upwards or downwards, it has recognized. Most northern quotations dropped during July, but only slightly, and in that very fact suggesting that the end of the long decline is in sight. Buying has been considerably heavier, though not altogether as heavy as is usual at a time which history finally shows to have been distinctly a bottom point. The purchases have been fairly numerous and have covered fairly extended deliveries, frequently to the end of the year, but the individual purchases have not averaged as great, in point of tonnage, as is expected from the buyers. Early in the month the central western market was expected to respond to the coke market, the operators insisting upon \$2.50 for renewal of contracts for the second half, a high price relative to pig iron. Furnaces have contested this price, some even banking, but the operators have maintained their position, curtailing production to the extent that contracts were not renewed. The furnaces which accepted the price bought for July only, and another contest is marked with respect to August coke. The market is quotable as follows: Southern No. 2 foundry at Birmingham, \$10.50; No. 2X foundry, Philadelphia, \$15.50; No. 2X foundry, Buffalo, \$13.75; No. 2 foundry, Cleveland, \$14.75; No. 2 foundry, Chicago furnaces, \$14.75; at valley furnaces (90 cents higher, delivered Pittsburgh) Bessemer, \$15.75; basic, \$14.35; No. 2 foundry, \$13.75; forge, \$13.50.

Steel

The market for billets and sheet bars has increased slightly in strength, to the extent that buyers are making less effort to break prices. At no time has steel been otherwise than scarce. In sympathy with cut prices on wire products rods have declined slightly. The market is quotable at \$26.50 for billets, \$27.50 for sheet bars and \$28 for rods, at maker's mill, Pittsburgh or Youngstown.

Finished Steel

Regular prices are as follows, f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.45 cents.

Shapes, 1.45 cents.

Steel bars, 1.40 cents, base.

Common iron bars, 1.65 cents, Pittsburgh; 1.57½ cents, Philadelphia; 1.50 cents, Chicago.

Wire nails, \$1.70, base; plain wire, 1.50 cents.

Sheets, blue annealed, 10 gage, 1.70 to 1.75 cents; black, 28 gage, 2.25 cents; galvanized, 28 gage, 3.30 cents; painted corrugated, 28 gage, 2.45 cents; galvanized corrugated, 28 gage, 3.35 cents.

Merchant steel pipe, 79 per cent off list for ¾ to 3-in.

Steel boiler tubes, 3½ to 4½-in., 69 per cent off list.

Standard railroad spikes, 1.70 cents, Pittsburgh; 1.75 cents, Chicago.

Button head structural rivets, 2 cents; cone head boiler rivets, 2.10 cents.

Case-Hardening and Heat-Treating of Steel, "a book of useful information and practical rules" (38 pages), has just been issued in its fifth revised and enlarged edition by the Ideal Case-Hardening Compound Co., U. S. Rubber Co. Bldg., New York.

Evolution of Methods of Handling Slime. V.

The Rand, South Africa.

By H. N. Spicer.

In the article published last month, slime treatment on the Rand was revised in a general and historical way. It is proposed now to describe in greater detail some of the special methods that have been developed or introduced there from

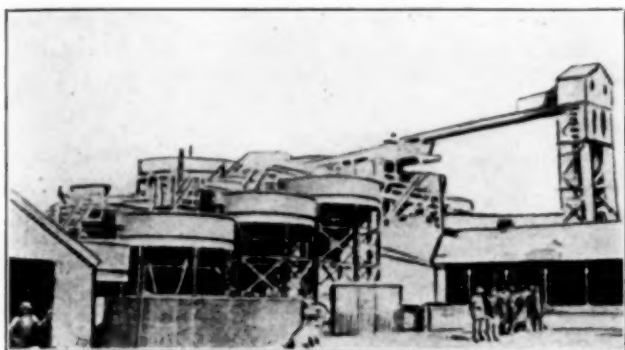


FIG. 1.—SLIME TREATMENT CONES AT MEYER AND CHARLTON

time to time, and to consider the practice at some of the individual mills. As stated in the last article, intermittent decantation has been the accepted method of recovering dissolved gold from slime, from the time of the first commercially successful attempt at the Primrose mine in 1894 until several years ago; and despite the introduction of other methods is still the leading process for slime treatment.

The first complete slime plant to operate continuously at a profit on slime coming directly from the stamps was erected at the Crown Reef mine about the middle of 1896. Settling pits were used for collection and decantation, and milk of lime was employed to assist settlement. The collected slime was mixed with cyanide solution and pumped to treatment vats where intermittent settling and decantation took place. This plant, though crude, was the forerunner of the present design of intermittent decantation as used today on the Rand.

Efforts to Supplant Intermittent Decantation

On account of the very evident disadvantages and drawbacks of the process, efforts have been made from time to time to abandon it in favor of some less cumbersome and more efficient method. One of the first attempts in this direction was made at the Robinson mine in 1897, where an adaptation of the Deebie slime vat was used. The Deebie machine, which had been introduced from Australia, was nothing more than a paddle agitator with a provision for raising the arms out of the pulp while the slime was settling. As used at the Robinson, the agitator tank was fitted with a filter bottom. After agitation, and during decantation and settlement, a vacuum was created beneath the filter for the removal of more solution than was possible by decantation alone. By this combination small charges of slime could be dewatered to about 28 per cent. moisture, and in successive periods of thickening, dilution and agitation with cyanide and wash solutions, the slime was impoverished and finally discharged to the dump.

This process gave promise of great results: it not only reduced the quantity of solutions to be handled, but yielded a gold solution of much better grade than was obtained by direct decantation. It developed weak points, however, in the excessive wear and tear on the filter bottom, and in the cost of operating the vacuum pumps, and was finally abandoned. A point of interest that should not be overlooked is that this process may be considered as the first attempt to use vacuum filtration on the Rand.

First Attempt at Continuous Slime Treatment.

While the Deebie slime vat was being tested at the Robinson, a small experimental plant for continuous decantation in cones was in operation at the City and Suburban mine. The preliminary results obtained were so encouraging that a large plant was designed for the Van Ryn, which was to have been erected in 1899, but owing to the Boer war was not built until 1903.

The underlying principle of the process was to pass the slime pulp through a series of conical tanks, so arranged that the thickened underflow from the first would gravitate to the second, and so on. The thickened slime entering the successive cones was diluted and washed with an inflow of barren solution, and at the same time an enriched solution overflowed. By this means it was expected that the soluble gold would gradually be washed out of the slime. But a serious obstacle was encountered in getting a regular cone discharge that contained even a reasonably low percentage of moisture; in other words the cones did not prove efficient as uniform thickeners, and it was impossible to thoroughly wash the dissolved gold from the slime.

This attempt at continuous decantation was not without value, however, even though it failed of its original intention. It showed clearly the advantage to be derived by impoverishing slime as much as possible prior to filtration, and this knowledge was used by the same engineers who later built the Meyer & Charlton and New Goch Mills. In designing these plants, the idea of continuously decanting gold-bearing solution from the slime was retained, but plate-and-frame presses were added as a means of washing out the last traces of dissolved gold.

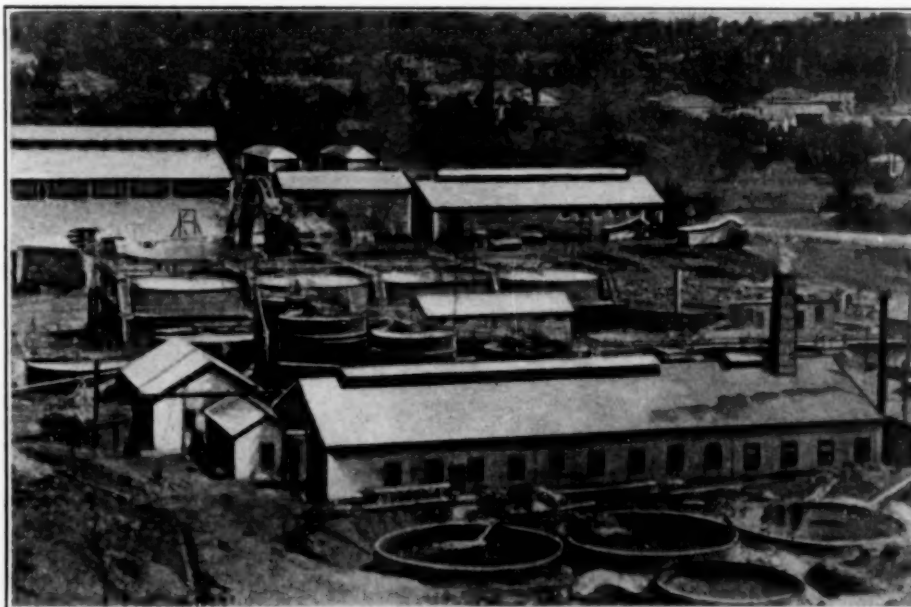


FIG. 2.—NEW GOCH MILL, SHOWING CONES FOR SLIME TREATMENT

Thus a combination of continuous decantation and filter pressing was developed on the Rand, but was never widely adopted. Filter presses had been used successfully in the mills of Western Australia prior to their adoption on the Rand. The expense of their maintenance and operation, however, was too great to be borne by low-grade ore, with the consequence that the combination did not prove economically successful, and was

never a serious competitor of intermittent decantation. In Fig. 1 is shown the cone decantation plant at the Meyer & Charlton. This was built in 1905 and is still in operation. Fig. 2 shows the plant of the New Goch Company with the decantation cones in the center of the photograph.

Nichols' Method of Slime Settlement.

During recent years there have been but few attempts to supplant the recognized system of intermittent decantation. Notice should be taken of the effort to displace slime collecting tanks by a device embodying the principle of accelerated settlement, *i. e.*, continuously removing the settled solids which acted as an obstacle to the free settlement of the solids above. Considerable work was done along this line with the Nichols slime dewaterer which removed the slime as fast as it settled on to a belt traveling slowly up the inclined bottom of the slime receptacle.

This process was effective in producing thickened slime, which was discharged at the head pulley with about 30 per cent. moisture. This was a great improvement over the results ob-

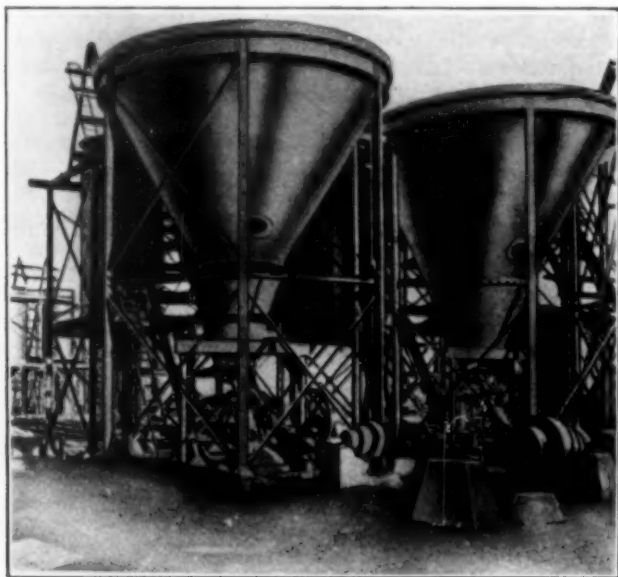


FIG. 3—ARBUCKLE CONES AT BENONI MILL

tained by settlement in slime collectors, but the small capacity of the machines was a disadvantage and they were found impractical.

The Adair-Usher Process.

In 1909 a company was formed to operate the Adair-Usher process of washing and decanting slime, and a plant was built at the Robinson mine. In this process the slime was collected in large settling tanks as for ordinary decantation, and after the water was decanted the thick pulp was transferred to the Usher treatment vat where it was mixed with cyanide solution.

The Usher treatment vat had either flat or concave bottom, and was fitted with a central vertical tube connected at the bottom with perforated pipes radiating from the center, parallel with and near the bottom of the vat. The central tube was 10 or 12 inches in diameter and projected several feet above the top of the vat. At the bottom it was enlarged into a chamber 4 to 6 inches deep and about 18 inches diameter, closed at the bottom by a flange to which the radiating pipes were attached by elbows.

In operation the slime was transferred from the collector to the treatment vat, and at the same time cyanide solution was admitted through the central tube. The solution passed out through the perforations in the radiating pipes, rising and mixing with the slime. The solution and slime formed a thin pulp which gradually rose until it filled the vat to the desired height. At this point the charge could be circulated in the vat by means of pumps until dissolution of the gold had taken

place. Barren solution was then introduced through the central tube, the pressure being so regulated as to keep the slime in suspension but leave from three to six inches clear solution on top. Decantation then commenced and the clear solution was drawn off continuously for precipitation at the same rate at which the washing solution was admitted. This operation was continued until the gold-bearing solution was displaced, when the inflow was stopped. The effect of the operation was to keep the slime in suspension, at the same time maintaining several inches clear solution on top, and gradually displacing the valuable solution from the bottom upward. In like manner the slime could be washed with water, and, after settlement and decantation, sluiced to the dump.

This process was operated on a large scale, and is reported to have given good metallurgical results. It required delicate adjustment, and difficulty was experienced in preventing the clogging of the pipes. Its advocates claimed better extraction, lower working cost, and a saving of one-third in the plant required for ordinary decantation. At the Robinson mine the process was finally replaced by a large, modern Butters filter.

The Crosse Method of Slime Treatment.

Another attempt was made to supplant intermittent decantation by the use of the Crosse method of slime treatment at the Crown mines. As a preliminary step to the process, the slime was collected and thickened by settlement in the ordinary manner. The subsequent treatment was given in a conical vat of special construction. It was equipped with a central air-lift for maintaining the slime in suspension while the vat was being filled, and had also a loading well or inner concentric baffle extending about half way to the bottom. This provided an annular area free from disturbance, from which fairly clear solution could be decanted for precipitation. In conjunction with the treatment vat, another conical vat with concentric baffle but no air-lift, was used for the final settlement and decantation of the impoverished slime.

The operation was as follows: Dewatered slime from the collectors was pumped with cyanide solution to the treatment cone, and while the latter was filling, its air-lift was operated to keep the slime in suspension and aid solution of the gold. When the cone was full, agitation was discontinued, and the charge was circulated from the bottom of the cone through an outside air-lift, being delivered again inside the circular baffle of the cone. During this operation the nearly clear solution in the quiet annular zone was being decanted for precipitation, and barren solution in equal quantity was being added to the circulating slime. When circulation had continued long enough to dissolve and remove the gold, the pulp was transferred to the conical settler for the recovery of solution by settlement and decantation.

The Crosse method continued in use at the Crown mines for about two years, but was eventually discarded, although it was reported to give an extraction of 95 per cent.

Arbuckle Cones.

The last attempt to supersede standard decantation, other than adopting vacuum filtration, was made at the Benoni mine in 1910. At that time a large plant was erected to operate the Arbuckle process of continuous decantation in large cones. A view of these devices under construction at the Benoni is given in Fig. 3.

The cones were fitted with circular baffles to assist settlement. The inventor proposed to use inclined screw conveyors to elevate the thick slime from the bottom of one cone to the top of the next, but the scheme was a failure. The greatest difficulty was encountered in maintaining uniform conditions which would yield a clear solution overflow and a thick underflow that could be elevated by screws. After making several alterations the entire slime plant was abandoned in favor of the regular decantation process.

Crushing in Cyanide Solution.

To the same engineers who designed and built the Meyer & Charlton and New Goch mills must be given the credit of first

adopting the practice of crushing in cyanide solution. As mentioned in the last article this practice had been attempted on a small scale as early as 1892 but was abandoned. With this minor exception, and until the Meyer & Charlton and New Goch mills were built, it had been customary on the Rand to crush in water. The disadvantages of the system, particularly in the resulting slime treatment, have already been referred to: the necessity and difficulty of dewatering, and the large and cumbersome plant required for decantation.

Notwithstanding the fact that apparently excellent work was done at the Meyer & Charlton and New Goch mills by crushing in solution, a number of difficulties arose. Chief among the arguments against the process were the impossibility of accurately sampling the ore, and the difficulty of overcoming the bad effects of cyanide on the amalgamation plates. In the light of our present metallurgical and mechanical knowledge it would appear that these difficulties should not be insurmountable; but the fact remains that the practice has been generally abandoned on the Rand. The Meyer & Charlton is today the only mill crushing in cyanide solution, and it is probable that the practice would be abandoned there but for the fact that the mine probably would be exhausted in a few years, and the prospect does not warrant the capital expenditure for the necessary changes.

Within the last two years the area of amalgamated surface used per ton of ore treated has been greatly reduced, so that the task of keeping plates properly dressed is not as great as formerly. In view of this great change the writer ventures the opinion that it will not be long before the other obstacle to crushing in solution, viz., sampling, also will be overcome, and that some engineer will again attack and solve the problem of crushing in solution.

Agitation of Slime.

In the beginning of slime treatment on the Rand, paddle agitators or mechanical stirrers were commonly used to hasten dissolution of gold by giving a thorough mixture of solids and solution. But with the wider adoption of intermittent decantation, more dependence was placed on centrifugal pumps to give the agitation and aeration required. In the usual decantation plant, as described in the last article, the charge of slime is transferred from one vat to another, or circulated within the same tank, by means of centrifugal pumps, and the agitation thus secured has been considered sufficient. Indeed with one or two recent exceptions no plants have been built with other provision for agitation.

In 1903 a plant was built at the Bonanza mine, in which the slime collectors were provided with paddle agitators. After settlement and decantation of the water, cyanide solution was added in the ratio of four parts solution to one of slime, and the pulp was agitated for eight hours. The charge was then pumped to a settler from which solution was decanted for precipitation. The thick slime was again returned to the agitator, mixed with barren solution in the same ratio as before, and given a short agitation. After settlement of the slime, the solution was decanted, being used for the treatment of the next charge of slime. The impoverished slime was finally pumped to a settler filled with water, and after final settlement was sluiced to the dump.

The extraction by this system at the Bonanza mill was given officially as 83 per cent. Although the process was fairly efficient from a metallurgical point of view, the cost of operating the agitators was too high and the method was never widely adopted.

Modern Agitators Introduced.

The introduction of vacuum filtration on the Rand has necessitated the use of modern forms of agitators which have been so widely used in other countries, and today the Brown or Pachuca, the Hendryx and the Dorr agitators may be found in operation. Continuous agitation in a series of Pa-

chuca tanks has been tried at the East Rand Proprietary mines.

Owing to the sandy nature of the slime from the deep level ores, the continuous system has met with difficulty in preventing the classification of coarse particles and the consequent accumulation of this material in the tanks. This has been true particularly of cone-bottom agitators. The Dorr mechanism, however, is operated in flat-bottom tanks, and absolutely prevents the building up of solids.

Speaking broadly, Rand slime requires only from six to eight hours' agitation to get the gold in solution, and it is probable that if the ore were crushed in cyanide solution the time required for agitation would be materially lessened.

Vacuum Filtration.

The most striking change which has taken place in Rand slime treatment was inaugurated in 1910 when the first Butters vacuum filter was built at the Crown mines. In a comparatively short time following the operation of this plant, other vacuum filters were built at the New Modderfontein,



FIG. 4—SAND AND SLIME PLANT, MODDERFONTEIN B MILL.

Brakpan, Robinson and other mines. Today there are eight such installations with an aggregate capacity of 6500 tons of slime per day.

The mill at the Crown mines commenced operations in October, 1910. Its equipment consists of 160 heavy gravity stamps crushing in water, ten 22 ft. by 5 ft. 6 in. tube mills, amalgamation plates, cone classifiers, five 50 ft. by 10 ft. 6 in. sand collectors, twelve 50 ft. by 12 ft. sand treatment vats, five 56 ft. by 12 ft. slime collectors, Pachuca agitators and Butters vacuum filter.

The slime is first settled to about 50 per cent. moisture, mixed with cyanide solution in the ratio of two parts solution to one of solids, and agitated for about eight hours prior to filtration. Thus the agitation and filtration plants displace the first and second treatments in the ordinary decantation system. A further advantage is found in having to precipitate only two tons of solution per ton of slime instead of three tons as in decantation. The extraction probably is 5 per cent. better than in good decantation practice.

With the exception of the fact that the ore is crushed in water, this mill may be considered the first up-to-date plant on the Rand.

In Fig. 4 is shown the sand and slime treatment plant at the Modderfontein B mine. The ore is crushed in water, and classified into sand and slime by means of cones. Three 50-ft. slime collectors, shown in the right center of the view, are used to dewater slime by decantation, after which it is pumped with cyanide solution to the four Pachuca agitators. A gravity vacuum filter plant is used, and the discharged slime is sluiced to settling ponds for the recovery of the water.

Recovery of By-Products in the Modern By-Product Coke Oven Plant*

By C. A. Meissner

Chairman, Coke Committee, U. S. Steel Corporation

The recovery of the by-products from the gases evolved in the coking process in a modern by-product coke oven plant—namely, gas, ammonia, sulphate of ammonia, and tar as well as benzol—is a very broad subject and I will try to confine myself as closely as possible to the points of main interest.

Briefly, the gas as it leaves the ovens through the foul gas

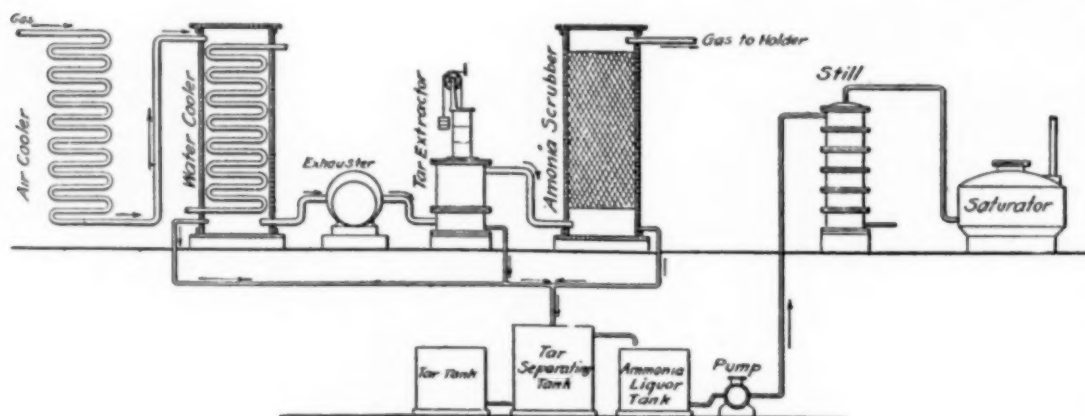


FIG. 1.—THE INDIRECT AMMONIUM SULPHATE PROCESS

main, located above the ovens, is taken over to the by-product plant in large mains and ordinarily is there cooled, the tar extracted, naphthalene thrown down as far as possible, the ammonia is scrubbed out of the gas by passing it through water towers or other apparatus, weak ammonia liquor is distilled, the ammonia passed into lead-lined saturators containing sulphuric acid and sulphate of ammonia is formed, or the distilled ammonia is placed in tanks and shipped as strong ammonia liquor. This is an outline of the *old indirect process*.

In the *direct recovery process* the scrubbing of ammonia from the gases is avoided by passing the gases through the saturator after the tar separation has been accomplished. In some of the so-called direct processes the tar is separated by cooling the gases and in this case a certain proportion of the ammonia is precipitated with the tar and must be distilled. In some of the direct processes the tar is separated without precipitation of the ammonia salts. These latter processes are, therefore, more preferably called direct than the processes where some of the ammonia is precipitated, which should be more properly called semi-direct.

There is also another process in which the sulphur contained in the gases is utilized, generally referred to as the "thio-sulphate process," of which I will give later a brief but more detailed description.

We have, therefore, at present really four processes that are largely used all over the world for recovering by-products:—namely, the *indirect*, the *semi-direct*, the *direct*, and the *thiosulphate*.

The effect of the coking time upon the recovery of by-products, particularly ammonia, is a subject that has not been fully worked out. Apparently the longer coking time increases the percentage of recovery of ammonia and the losses in ammonia become greater as we decrease the coking time up to a certain point. I doubt whether this point can at the present time be definitely settled upon, because there are other reasons for ammonia losses than the coking time itself. We have generally felt that with a short coking time we do not get as much of the total available ammonia as at plants having a longer coking time.

*A part of a paper on "The Modern By-Product Coke Oven," presented at the recent meeting of the American Iron and Steel Institute.

I understand that in Germany they recover up to 95 per cent of the total ammonia available in the coal. A factor that assists the Germans is that their coal is almost invariably washed and, therefore, contains a certain amount of moisture, which is effective in obtaining a larger percentage of the available ammonia.

So far as our experience has gone, we seem to have no material difference in our recovery percentage when running between 16½ and 20 hours coking time. We have practically no experience over any period of time on 24-hour coking time, excepting at Farrell, but there the conditions are to my mind

not of such a nature as to be quite comparable to our conditions at the other plants. This subject is undergoing careful study at all our plants.

The same applies more or less to the question of whether a hot top of the oven is more likely to increase the loss of recoverable ammonia than a cooler top. The general impression so far has been that the

cooler top is the better in this respect. Points like these have to be carefully balanced, because from them arises the question of what is more economical to produce, a good blast furnace coke or a larger by-product recovery. The object of the Steel Corporation has always been, and I think rightly so, to make a good furnace coke and then to recover as much of the by-products as is consistent with this. The money loss through inferior coke and its detrimental effect on blast furnace practice soon offsets any slight gain through increased ammonia yield at the coke oven.

I believe you will be interested at this time in a few illustrations and a short description of the different by-product apparatus for extracting the tar, ammonia and benzol from the gas, which latter is then returned to the ovens for heating or carried off as surplus gas to the steel plant or other places where it is to be used.

The Indirect Process for Recovery of Ammonia

In the indirect process (Fig. 1) the gas coming from the ovens is air- and water-cooled to allow the deposition of tar and combined ammonia liquor, and is then passed through scrubbers where the free ammonia contained in the gas is

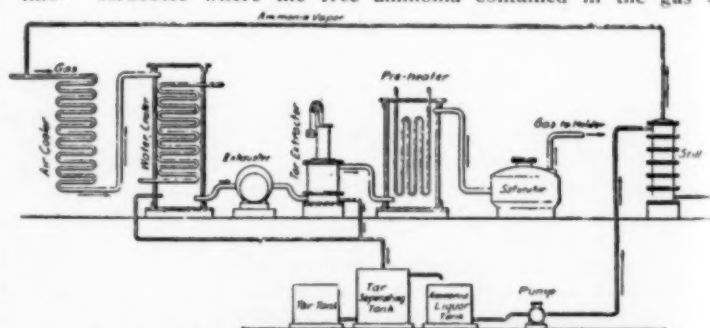


FIG. 2.—KOPPERS' DIRECT AMMONIUM SULPHATE PROCESS

washed out by means of water. This weak ammonia water, together with the ammonia liquor separated from the tar, is then treated with steam and milk of lime in a still, and the ammonia vapors either passed into an acid saturator or else condensed into a strong ammonia liquor, depending on whether it is desired to produce sulphate or liquor.

Koppers Semi-Direct Sulphate Process

In this process (Fig. 2) the gas leaving the ovens is first air- and water-cooled to a temperature of 104 deg. Fahr. This throws down most of the tar, the water vapor, the combined ammonia and some free ammonia.

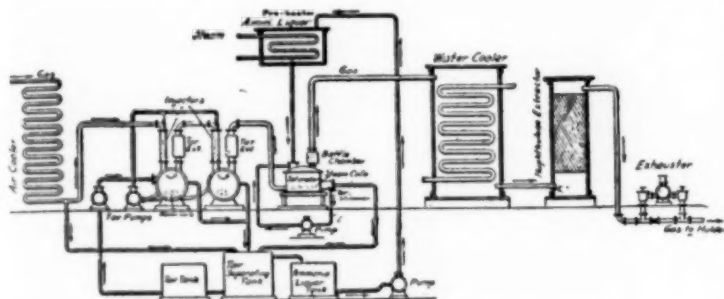


FIG. 3.—OTTO DIRECT AMMONIUM SULPHATE PROCESS

The ammonia liquor is separated from the tar and treated in stills with steam and milk of lime in the usual way, the ammonia vapors being either converted into ammonia liquor or else returned to the system for conversion into sulphate, by entering the gas main at a point prior to the water coolers and traveling with the gas to the saturator.

The gas, after leaving the water-coolers freed from most of the tar, passes through an exhaustor to P. & A. tar extractors, where the remainder of the tar is removed. Thence the gas is returned to a heater where the temperature of the gas is raised to about 176 deg. Fahr., the heating medium being exhaust steam or the uncooled gas from the ovens, usually the former in the later plants.

The heated gas then passes into the saturator, where the ammonia in the gas is neutralized by the sulphuric acid with the formation of ammonium sulphate. Leaving the saturator at a temperature of about 120 deg. Fahr., the gas passes without further cooling to the gas holder for return to the ovens and its other uses.

Otto Direct Sulphate Process

In the Otto direct sulphate process (Fig. 3) the gas from the ovens is air-cooled to a temperature of about 200 deg. Fahr. and is then further cooled to a temperature a little above the dew point of steam, about 160 deg. Fahr., by means of a tar spray.

The object of cooling to about the dew point is in order to prevent the deposition of ammonia liquor, which would occur if cooled to a lower temperature, and thus necessitate the use of stills as in the other processes. By keeping the temperature a little above the dew point this ammonia remains as vapor in the gas. Experience has shown, however, that some ammonia is invariably thrown down with the tar.

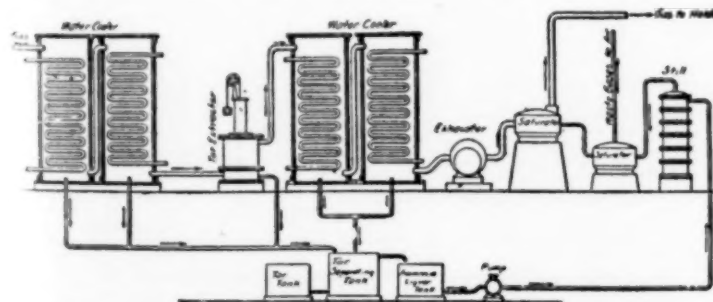


FIG. 4.—COLLIN SEMI-DIRECT AMMONIUM SULPHATE PROCESS

The spraying with tar is performed by Koerting injectors in a two-compartment tar tank in series, so the gas is twice sprayed. The temperature of the spraying tar is kept at the right degrees by means of water-cooling pipes in the tank.

The surplus tar washed out of the gas overflows into a regular separating tank, where the ammonia liquor which has come

down with the tar is removed. The amount of this liquor is small.

The tar-washed gas then passes through a stationary bell similar in function to a P. & A. tar extractor, where the last of the tar is supposed to be removed, but on account of the high temperature of the gas some tar continues to remain therein.

The gas then passes through a covered gas main to the saturators, where neutralization of the ammonia occurs with the formation of ammonium sulphate, which is ejected and dried in the usual way.

On account of imperfect separation of the tar from the gases, some tar is always deposited in the saturators; therefore, it is equipped with a lead dam and siphon to allow the top portion of the mother liquor to be withdrawn into an open top tank in which the tar is skimmed off and the mother liquor returned to the saturator.

On account of the gas entering the saturator being fairly well saturated with water vapor, which, if deposited here, would weaken the acid bath and prevent proper absorption of the ammonia, the saturators are equipped with steam coils made of lead, and the bath is kept heated by means of steam to a temperature high enough to insure the retention of the water vapor in the gas.

The ammonia liquor separated from the tar is heated by steam coils in a small tank, and is then introduced direct into

COLLIN DIRECT SULPHATE PROCESS.

BY
KOLNER BERGSCHAFT FÜR KOLLEKTION, BERLIN

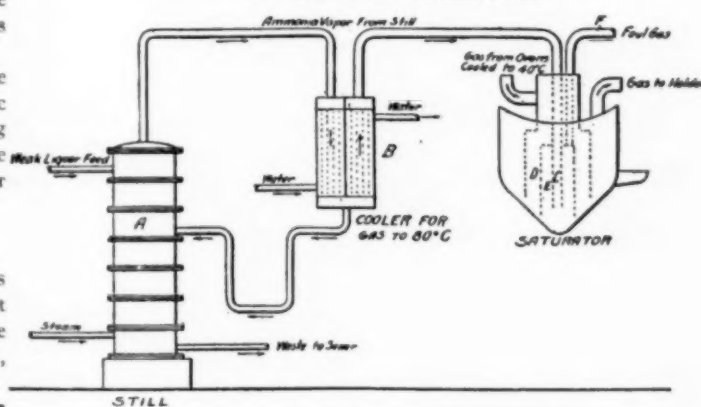


FIG. 5.—COLLIN DIRECT SULPHATE PROCESS

the saturator. After leaving the saturators, the gas enters a tank containing brick baffles to allow separation of the acid and thence to horizontal tubular water-coolers, where the gas is cooled to separate the water and as much naphthalene as possible. At some places a further naphthalene extractor is being installed.

After leaving here, the gas is drawn through an exhaustor and pumped to the gas holder, ovens, etc.

Temperatures taken at a representative plant at the various stages of the operation were as follows:

Entering Koerting injectors.....	200° F.
After spraying with tar.....	162° F.
Entering saturator	160° F.
Leaving saturator	185° F.
Entering water coolers.....	171° F.
Leaving water coolers.....	102° F.

Collin Semi-Direct Sulphate Process

In this process (Fig. 4) the gas from the ovens passes through the usual horizontal tubular water-coolers where most of the tar and combined ammonia are separated, then through a P. & A. tar extractor where the remainder of the tar is separated. The cleaned gas then passes through another set of water-coolers exactly similar to the first set, and then through the exhaustors to the saturator.

Two saturators in series are used in this process, set at different levels in the building.

The cleaned gas enters the upper saturator, the bath of which is kept at about 25 percent free acid, and the liquor from this

The temperatures at one plant where this process is in operation were as follows:

Gas entering first set of water-coolers.....	212° F.
Gas entering the P. & A. tar extractor.....	113° F.
Gas leaving second set of water coolers....	73° F.
Gas entering saturator.....	77° F.
Gas leaving saturator.....	100° F.

Experiments for a modification of this process are being conducted along the following lines:

The gas from the ovens will be treated in one set of horizontal coolers, P. & A. tar extractors, and another set of horizontal coolers as above described.

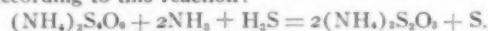
In the first set of coolers, however, the ammonia liquor will be used for cooling instead of water. The ammonia liquor will thus become heated to a temperature of about 194 deg. Fahr. in its action of cooling the hot gases from the ovens.

This preheated liquor, and any vapor which may be evolved, will be run to a superheater and brought to a temperature of about 300 deg. Fahr., which is considered sufficient to decompose the compounds of ammonia (chloride, carbonate, etc.).

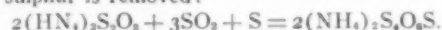
The ammonia vapor evolved passes from here directly into the saturator. The superheater will be heated either by combustion of surplus gas from the ovens, or by utilizing the waste heat from the chimney flues.

Feld Direct Sulphate Process

In this process* (Fig. 6) the sulphur in the coke oven gases is utilized to produce most of the sulphuric acid required for the neutralization of the ammonia in these gases. After leaving the ovens, the gases pass through the usual coolers, exhausters and tar extractors, and are then washed with a solution of ammonium polythionate, which absorbs the ammonia from the gases, forming ammonium thiosulphate and precipitating sulphur according to this reaction:



This mixed solution and precipitate is treated in a tank provided with mechanical stirrers with sulphur dioxide formed by burning in a suitable oven, some of the sulphur previously precipitated; the thiosulphate is thereby regenerated to ammonium polythionate, according to the following reaction, and the precipitated sulphur is removed:



When the oxidation is complete, the solution of polythionate is heated with exhaust steam or otherwise to a temperature of

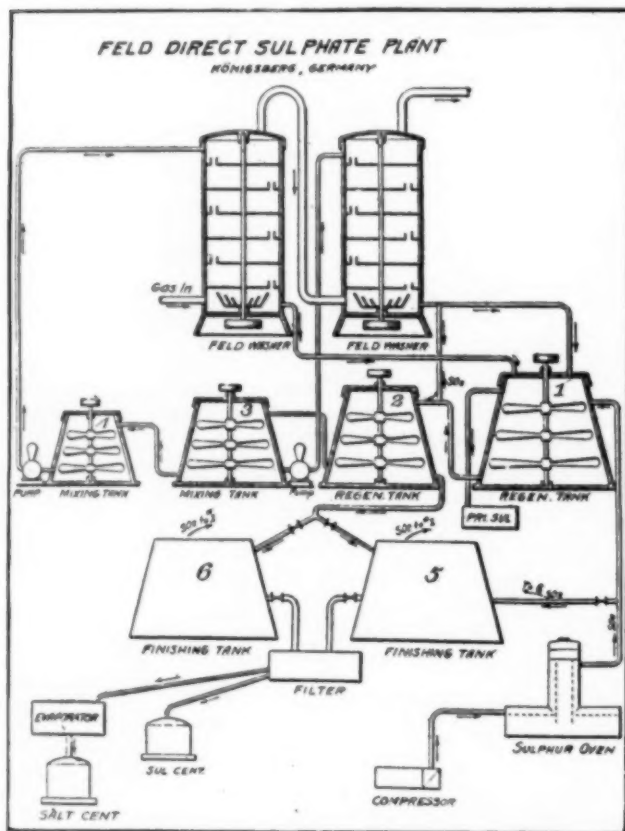


FIG. 6.—FELD DIRECT SULPHATE PROCESS

bath is used as the saturating medium in the second or lower saturator, into which pass the ammonia vapors from the stills which are used in this similarly as in the Koppers process.

One advantage claimed for this system of treating the ammonia in two saturators, one for the direct gas and the other

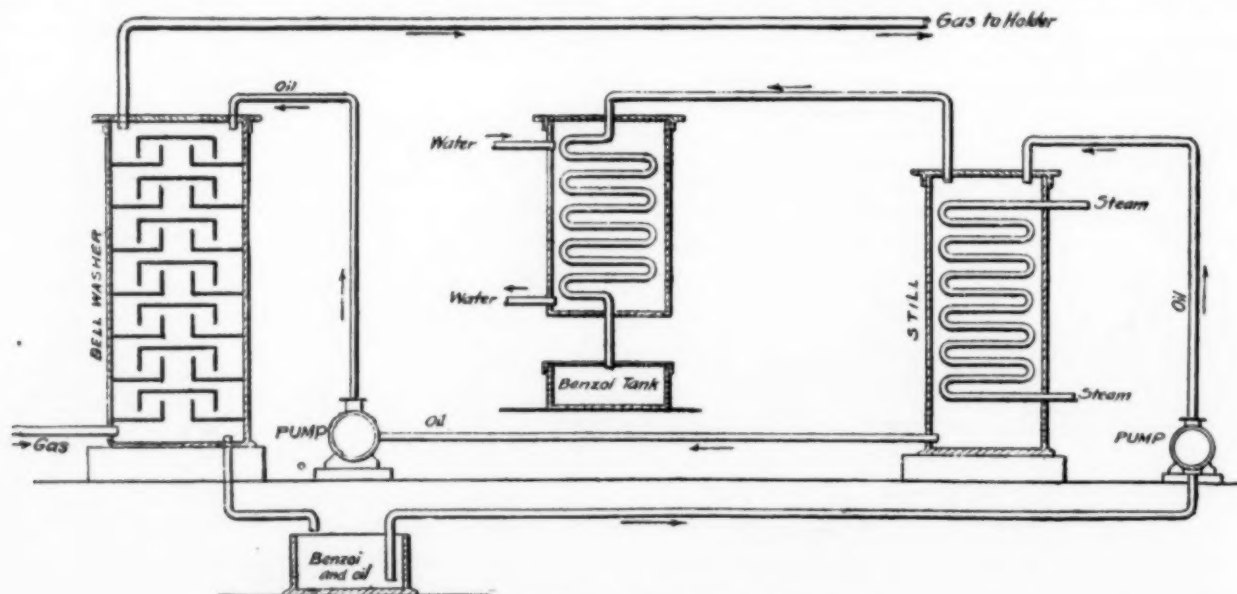


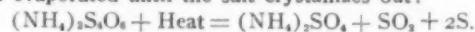
FIG. 7.—APPARATUS FOR RECOVERY OF BENZOL

for the still vapors, is that the "stink" gases (H_2S , CN , etc.) from the latter are at once eliminated from the system, escaping from the second saturator into the air and thus never coming into contact with the gas.

60 deg. C. to 70 deg. C. until all the ammonium polythionate is decomposed into ammonium sulphate, sulphur dioxide, and sulphur. The sulphur dioxide is used for further regeneration.

*See also this journal, vol. X, p. 395 (July, 1912).

the sulphur is filtered off, and the solution of ammonium sulphate is evaporated until the salt crystallizes out:



Recovery of Benzol

Benzol is defined as a colorless, inflammable, liquid compound having the chemical formula C_6H_6 .

Benzol is recovered from coke oven gases by scrubbing them with light oil, in washers of various types, after the ammonia has been separated from the gases; that is, after the gases leave the ammonia scrubbers in the indirect process, or after the gases issue from the saturator in the direct process. Some benzol is also precipitated with the tar.

The oil used for scrubbing is usually in this country a light oil of specific gravity about 0.8; it should be neither too thin, in which case long enough contact with the gas is not obtained, nor too thick, in which case there is a tendency to solidify.

After scrubbing, the mixture of washing-oil and benzol is conveyed to a still, where the benzol is driven off, with steam as the heating medium. The benzol so obtained is designated as "crude" benzol and contains about 50 per cent benzol. This is either shipped as such, or is purified by further distillation to various grades of benzol or fractionally distilled with separation of toluol and xylol when required. The oil used for scrubbing is used over and over again until it gradually becomes too thick by accumulation of naphthalene and tar.

The yield of benzol depends largely on the volatile contents of the coal; usually the higher the volatile matter the higher is the yield of benzol.

Uses of By-Products

Tar.—This is used largely for two purposes, namely, distillation for production of creosote and light oils and pitch, and for use in road making. Both of these uses of tar have increased very greatly in the last few years and the tendency for still further increase indicates a very large proportion of the future production will be similarly used. Tar is further being used successfully in open-hearth furnaces, replacing producer gas; also in heavy oil engines, providing it does not contain too much free carbon. It has also been burnt with success under boilers through specially devised burners.

Ammonia and Ammonium Sulphate.—The ammonia in the form of concentrated ammonia liquor is used in making anhydrous and aqua ammonia for refrigeration, and other purposes, in the production of soda ash, explosives, and in other lines of chemical manufacture. Sulphate of ammonia is very largely used as a fertilizer, although in some cases it is converted to ammonium hydrate for use in chemical manufacture. When used as a fertilizer it is usually mixed in definite proportions with other fertilized ingredients, such as acid phosphate, potash, etc., according to the conditions.

Coke Dust and Coke Breeze.—The coke dust is used to advantage in the steel mills in soaking pits, etc. Coke dust up to $\frac{1}{4}$ in. in size can also very profitably be burnt in specially designed grates under boilers. The coke breeze is sold for domestic purposes, having been screened and sometimes sized. In locations where coal is cheap the disposal of the coke breeze may at times be somewhat troublesome.

Surplus Gas.—The surplus gas obtained from the coke ovens, which has a value of 400 to 650 B.t.u. per cubic foot, depending on the coal used, is one of the most valuable by-products. It can be used for all sorts of heating purposes at the steel plant and its value in replacing coal for all purposes at one of our steel plants is equivalent to approximately one-half million net tons of coal per year, based on 40,500 cu. ft. of surplus gas being equivalent to one net ton of coal at that point.

This surplus gas is also used for illuminating purposes and can be piped long distances for this purpose. In Europe it is used quite extensively in gas engines. Experiments have also been made using it in the open hearth furnaces alone or mixed with blast-furnace gas, the latter method having been largely adopted in certain parts of Europe and I believe ultimately in this country will receive due consideration.

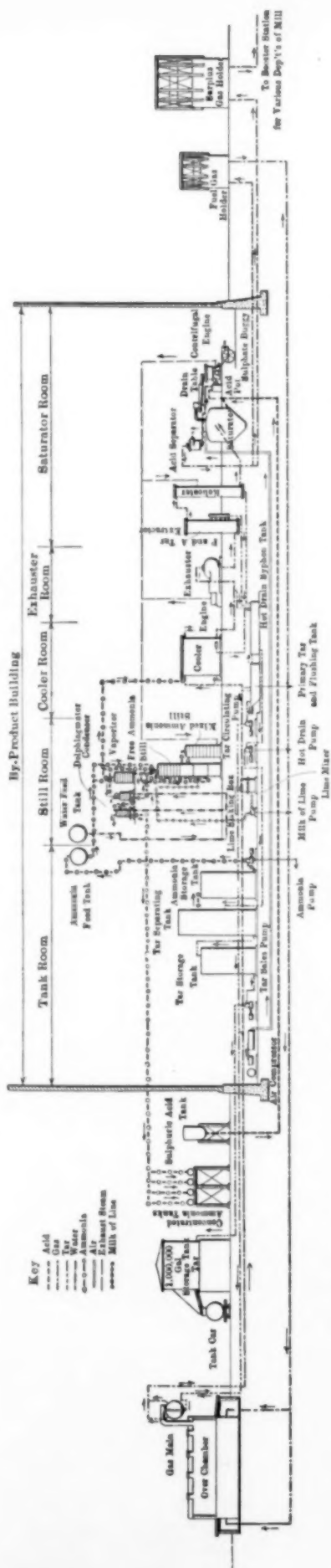


FIG. 8.—DIAGRAMMATIC SKETCH OF FLOW OF GASES, EXTRACTION OF VARIOUS BY-PRODUCTS, ETC., IN A BY-PRODUCT COKE OVEN PLANT

Benzol.—The principal uses of benzol and its products are:

- (1) As a motor fuel.
- (2) To enrich the illuminating power of gas.
- (3) In manufacture of aniline dyes.
- (4) As a solvent for rubber and similar substances.
- (5) In manufacture of gunpowder.

Production of benzol in Europe has increased enormously in recent years due to its increasing consumption as a motor fuel in place of gasoline. At the same time the price has steadily increased, more than keeping pace with the increased production.

Notes

The metal production of Idaho in 1912 is estimated by the Geological Survey to be valued at \$21,466,500, an increase of \$2,365,600 over 1911. The output of gold remained about the same, being valued at \$1,381,200. The silver output of 8,294,745 oz. was less than 1 per cent greater than in 1911. The production of copper increased about 2,340,000 lb., and the production of lead 11,629,132 lb. Record shipments of zinc concentrates were made, the production being 13,905,502 lb., an increase of 5,565,253 lb.

Recent publications of the Bureau of Mines include *Technical Paper No. 37*, "Heavy Oil as Fuel for Internal-Combustion Engines," *Technical Paper No. 44*, "Safety Electric Switches for Mines," and *Bulletin No. 51*, "The Analysis of Black Powder and Dynamite."

Synthetic tannin is reported to have been made by Dr. Edmund Stiasny, of the University of Leeds, England. The product, which is called neradol, is made from tar distillation products, the synthesis being carried out by sulphonating cresylic acid and combining it then with formaldehyde. The product yields a white color to tanned materials.

Cleansing of Sulphate Pulp.—It has been pointed out by Mr. Philip B. Sadler, of the Swenson Evaporator Company, Chicago, that by using a battery of blow tanks to systematically wash the liquor out of the pulp, this can be done with the least expenditure of water and the highest cleansing effect. Incidentally, this is one of the best methods for doing away with the very objectionable odor of the sulphate pulp mill. Pulp is blown under pressure from the digesters directly into the blow tanks, the battery being used in countercurrent system for washing. The small expenditure of water leaves a minimum of water to be evaporated and hence produces economies in this end. This is one of the several innovations which Mr. Sadler is introducing into some of the newer mills with which he is connected.

The Hoskins Manufacturing Company, of Detroit, Mich., has issued its illustrated bulletin No. 3, entitled *Hoskins Thermo-Electric Pyrometers*, which in addition to being a catalog of the well-known pyrometers of their manufacture contains a considerable amount of information of interest to pyrometer users.

The Bristol Company, of Waterbury, Conn., has issued bulletins 175 to 178. Bulletin 175 gives a brief illustrated description of a long-distance indicating electric resistance thermometer, which has recently been developed by this company and is especially adapted for accurate measurement of low temperatures over long distances. Bulletin 178 describes the Bristol wet and dry bulb recording thermometers, which have been designed for recording temperatures of wet bulb and dry bulb on the same chart, on the basis of which the humidity of the atmosphere can be computed.

The United States Metal & Manufacturing Company, 165 Broadway, New York, has recently added to its line of railway specialties the sale of the Lincoln arc welding and cutting machines, products of the Welding Materials Company. These machines will weld cracks and seams in locomotive fire boxes, flues in the sheet, engine frames, and other work of similar character, incidental to steam railroad material, also broken motor cases, truck frames, broken and worn armature shafts, etc.; steel, grey iron and malleable castings, and will cut off

heads, risers, mis-runs, rails, etc., and wreck steel structures, cut up scrap boilers, etc.

The Chicago Pneumatic Tool Company have just issued illustrated Bulletin No. 127 on pneumatic drills, reamers, wood borers, flue rolling and tapping machines and grinders. Their Bulletin No. 34L gives "general pneumatic engineering information"; it shows not only the large number of types of compressors made by this company, but should prove particularly useful on account of the various convenient tables and data which can be used in connection with compressor or compressed-air calculations.

The Rational Absorption of Hydrochloric Acid.—The article by Dr. Theodor Meyer on this subject, published in our May, 1913, issue (page 267), has been reprinted by the German-American Stoneware Works, 50 Church Street, New York City, and copies of this reprint may be had on application from this company. The German-American Stoneware Works are the American associates of the Deutsche Ton- und Steingewerke of Charlottenburg, in conjunction with whom Dr. Meyer developed the designs of absorption apparatus described in that article.

The first International Exposition of Safety and Sanitation ever held in America will take place in New York City from December 11th to 20th, 1913, under the auspices of the American Museum of Safety, 29 West Thirty-ninth Street, New York City. This is the only museum of this kind in this country, while there are 21 museums of safety in Europe. By a special act of Congress, exhibits from Europe and other foreign countries are to be admitted free of duty.

For the **Anglo-American Exposition**, which will be held in London from May to October, 1914, the Philadelphia Commercial Museum will undertake the organization of the American Industrial Section.

The Edison Storage Battery Company, West Orange, New Jersey, for its new building, now being erected for the manufacture of storage batteries, have placed through the New York office of the Quigley Furnace & Foundry Company, Springfield, Mass., one of the largest contracts for accurate-temperature furnaces ever placed. This contract is for fifty-nine of the Quigley overfired accurate-temperature furnaces burning oil fuel. The Edison companies have used this same type of furnace in all of their plants in the past, for a series of years.

The Tomboy Gold Mines Co., after operating two Hardinge conical mills for fourteen months, are installing two additional mills of the same type.

Volute Centrifugal Pumps.—Centrifugal pumps are divided into two general types—the volute pump and the turbine pump. The turbine pump is practically the converse of the water turbine, while the volute pump derives its name from the form of the casing, which is similar in shape to the involute curve. The Worthington catalog W-202, just issued by the International Steam Pump Co., 115 Broadway, New York, gives a profusely illustrated description of Worthington volute pumps. These are built in three standard designs—the single side suction type, the double suction solid case type, and the double suction pump with horizontally slit casing. The catalog also contains directions for installing, operating, and testing centrifugal pumps, and numerical tables useful in pumping practice.

Oxygen and Hydrogen Plants in Operation is the title of a little illustrated booklet showing the successful introduction of electrolytic oxygen and hydrogen plants of the I. O. C. system into quite a number of American works. The process was described in our Vol. IX, p. 471 (September, 1911), with additional notes in our Vol. X, p. 394 (July, 1912). The above pamphlet is published by the International Oxygen Company, 115 Broadway, New York City.

Protection of Iron and Steel is the title of a pamphlet issued by the Metal Treating & Equipment Co, U. S. Rubber Co. Bldg., New York. It deals with the "Standard" galvanizing process. This is an electrogalvanizing process, but only few technical details are given.

Recent Chemical and Metallurgical Patents

Gold and Silver

Rotary Vacuum Filter.—A rotary vacuum filter for slime pulp or for the separation of a valuable liquid from a finely divided solid has been patented by Mr. THOMAS BREAKELL, of Wirksworth, England. The main object of the invention is to filter slime pulp continuously and at the same time provide means for keeping separate the valuable solution and the wash solutions. The invention is along the line of the well-known Oliver and Portland types of vacuum filters, but differs from them in being a closed drum in which a vacuum is maintained and into which the several solutions are drawn and collected in different compartments.

As shown in Figs. 1 and 2 the filter consists of a closed drum or barrel *a*, having a filtering surface *b* and arranged to rotate in a suitable frame. Within the barrel is a receptacle *d* divided by a vertical partition into two compartments *f* and *g*. A space *h* is left beneath the receptacle. On the inner periphery of the drum are arranged numerous ribs *l* which serve to divert the filtered fluid into the proper receptacles. A slime feed-box is placed at *n*, the lower edge of which, *m*, serves also as a knife to scrape the filtered slime from the face of the filter. Suitable pipes and distributing rollers for applying wash solutions are placed at *s* and *t*, and *q* and *u*. Pipes for withdrawing the filtered liquids under reduced pres-

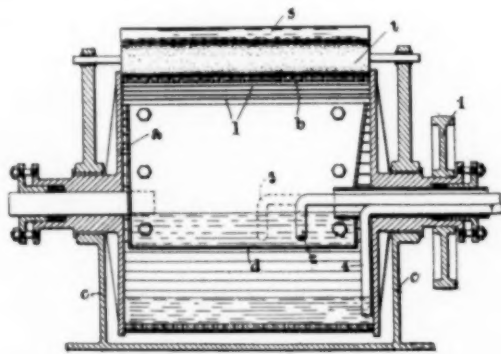


FIG. 1—VACUUM FILTER

sure enter the drum through the bearing at one side of the drum, and extend into the several receptacles for solution. In the drawing these pipes are numbered 2, 3 and 4. Their outer ends are connected with a vacuum pump.

In operation the drum is rotated and the vacuum applied. Slime is delivered into the receptacle *n* and thus brought in contact with the filtering surface on the rising side of the drum on which it forms the usual cake. The solution passing through the filter is diverted by the inner ribs into the receptacle *f*. At the top of the drum a wash of barren solution may be applied from the pipe *s*, being distributed over the surface of the cake by means of the roller *t*. This solution, on passing through the filter, is diverted by the inner ribs into the receptacle *g*. Similarly, on the descending side of the drum, a wash of clear water may be applied from the pipe *q* within a gauze distributor *u*. Part of the solution filtered at this point may pass into the receptacle *g* and the balance into the space *h*. The several solutions are removed by the pipes 2, 3 and 4.

It is not apparent that this filter offers any advantage over the better known types of drum filter, either in the method of feeding the slime or in the manner of keeping the solution separate. The use of the rollers in connection with the wash solutions may be advantageous in getting a thorough distribution over the cake and in filling slight cracks that may appear. (1,064,702, June 17, 1913.)

Zinc

Electric Smelting of Zinc Ores.—In Fig. 3 is shown a longitudinal central section of a rotary furnace in which Mr. AUGUSTIN L. J. QUENEAU, of Philadelphia, Pa., proposes to

smelt zinc ores by means of electricity. In contrast to the standard method of smelting zinc ores the inventor provides a large furnace in which a comparatively large charge can be treated at one time. The advantages claimed for the process by the inventor are that partly roasted or even raw sulphide ores can be smelted; that ores containing iron, copper, gold and silver can be treated efficiently; that the furnace lining can be made of material more resistant to the action of slag than

fire-clay; that ores not suitable to the present methods of smelting can be fluxed and treated by this process; and that preheated ore can be charged to the furnace, such preheating being accomplished, for instance, in the roasting kilns.

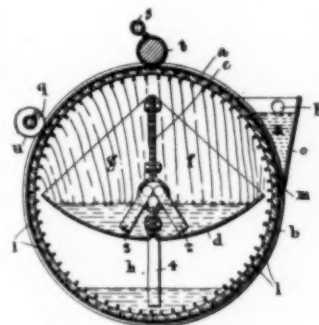


FIG. 2—VACUUM FILTER

Referring to Fig. 3, the furnace consists of a steel shell *k*, lined with an outer layer *a* of fire brick, and an inner layer *b* of chrome brick, the latter being inert to slags and zinc vapors. The furnace rotates on tires and rollers, being driven by band gear *f* and gear wheel *g*. Each end of the furnace is closed by a metallic plate *h* which is attached to the shell in such a way that it is held in elastic, adjustable contact with the end of the furnace and may adapt its position with expansion and contraction of the furnace. The end lining is made of a circular course of graphite bricks *n*, fire brick *p* and chrome brick *r*. A condenser *A* and prolong *B* at each end of the furnace are held in position by a casting *s*, and revolve with the furnace, being connected with the latter by means of a refractory connection *q*. The non-condensable gases issuing from the prolong pass up a flue *C*. The plates *h* are recessed at *x* to provide reliable electric contact with the ends of the carbon brick *n*. At the left end of the furnace this recess provides a path for a carbon or metallic brush *y* constituting one of the terminals of an electric circuit so that during revolution of the furnace the current will be transmitted to that end of the furnace and to the circular course of carbon bricks *n*. The other terminal of the circuit *z* makes contact with the metallic shell of the furnace. At the right end of the furnace the ring *j* is in electric contact with the shell and likewise with the plate *h* by means of the spring metal plates *o*.

The metal plates *h* at each end of the furnace are thus out of direct electric connection with each other, and are intended to be electrically connected by a molten fluid resistor

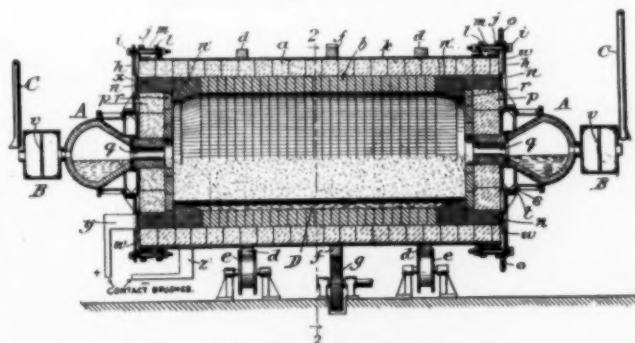


FIG. 3—ROTARY ELECTRIC ZINC FURNACE

D which spans the non-conducting area between the plates. Molten cast iron of such composition as to have high specific electric resistance and high fluidity at relatively low temperatures, is used as such molten resistor.

In operation, the furnace having been preliminarily heated, a known amount of molten resistor is introduced after which the furnace is charged with preheated roasted ore and fuel. The furnace is then rotated slowly and the processes of reduc-

tion, distillation and condensation proceed. The passage of the electric current maintains the necessary thermal conditions. When the reduction is complete the furnace may be tapped of its slag and matte, if any be formed. The same aperture may be used for charging and tapping. The distilled zinc is condensed in the vessels *A*. The charge may be fluxed so as to produce a molten slag and copper-bearing material can be added to form a matte to gather the precious metals. (1,064,992, June 17, 1913.)

Iron and Steel

Melting Ferromanganese.—Messrs. Wilhelm Schemmann and Jegor Bronn of the Rombacher Huettenwerke, Germany, are continuing their experimental electric furnace work with ferromanganese. Electric steel furnaces of various types have recently gained a new field of application, as they are being widely used in Europe to keep a liquid supply of ferromanganese ready at the converter plant, thereby saving in alloy and making the deoxidation more efficient than before. The direct heating of ferromanganese by the electric arc volatilizes too much metal as a brown smoke and can not be depended upon. The arc voltage amounts to 45 to 75 volts. The simple direct resistance heating was perfect as far as the metal

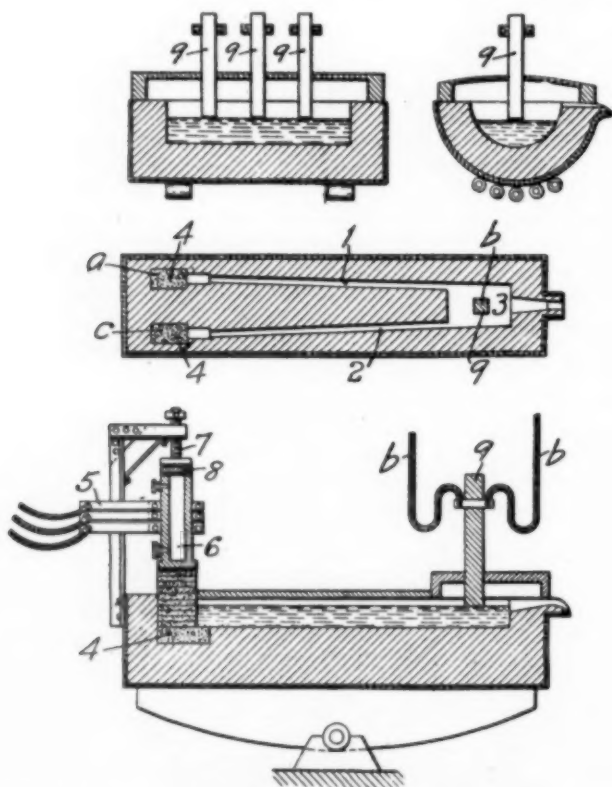
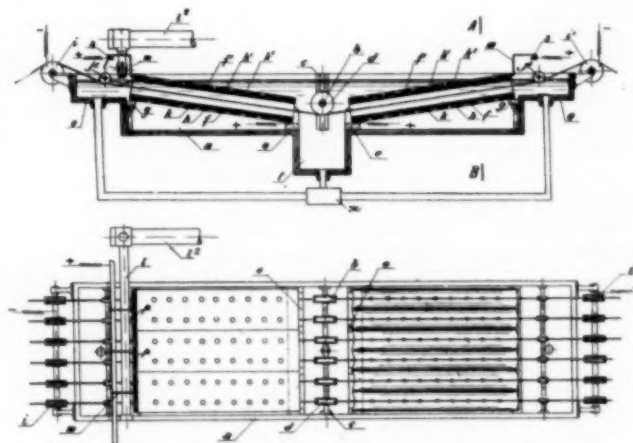


FIG. 4.—MELTING FERRO-MANGANESE BY A COMBINED ARC AND RESISTANCE METHODS (UPPER DIAGRAMS FOR THREE-PHASE CURRENTS, LOWER DIAGRAMS FOR SINGLE-PHASE)

was concerned, the slags however sometimes offered difficulties in removing. The two inventors, therefore, propose a combination process of arc and resistance heating shown in Fig 4 for 3 or monophase current. The carbon is lowered to such an extent that it just touches the surface of the bath and that the voltage drop between the carbon and the metal amounts to only from 16-18 volts. This enables one to heat the metal by resistance and the slag by the "semi-arc" method and thus saves considerably in carbons and metal. (1,061,016, May 6, 1913.)

Continuous Galvanizing Process for Strips of Metal, Wire, etc.—Mr. Frederico Werth of Milan, Italy, has designed a new apparatus for a continuous electrogalvanizing process which will be readily understood from the drawings, Fig. 5 representing the electrolytic tank in longitudinal section, Fig. 6

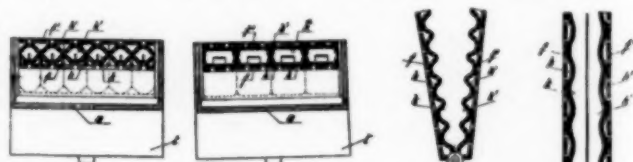
being a plan, Figs. 7 to 10 showing various forms of the anode, the last one to be used for treating sheet metal plates in vertical position. The corrugated form of the anode consisting of a plurality of channeled and perforated members, both upper and lower members, is a special feature of the design. An adjustable guide wheel and a well are provided at the center of the bath, and the electrolyte is pumped from the well to the extensions at opposite ends of the tank. (1,065,090, June 17, 1913.)



FIGS. 5 AND 6.—CONTINUOUS ELECTROGALVANIZING PROCESS

Cupola Furnace.—Mr. William Newton Best of New York introduces what seems to be a novel feature in cupola melting by using crude oil or any other liquid hydrocarbon as fuel instead of coal or coke. Figs. 11 to 13 are self-explanatory, showing a bath furnace combined with the cupola like a fore-hearth. The flame passes from the combustion chamber through the bath furnace and then upwardly through the cupola. The metal may be tapped directly from the cupola into a ladle if cast iron is desired. If dense iron is to be made, the metal can flow into the hearth and accumulate and be thoroughly mixed by poling. (1,061,158, May 6, 1913.)

Regenerator or Hot Blast Stove.—Messrs. Max Schroeder of Berlin and Hugo Reinhard of Oberhausen, Germany, describe several designs of vertical regenerators filled with refractory material through which air or gas are forced by a compressor. Their invention permits reducing the temperature of the waste gases to below 100 deg. and even as low as 50 deg. Centigrade and allows to attain the highest possible furnace temperatures, whereas the thermal efficiency of the regenerators now in use is only about 50 per cent and the gases leave at a temperature averaging between 300 deg. and 500 deg. Fig. 14 illustrates in vertical section an arrangement for heating the air blast only. This is to be employed for gases of high calorific value. The arrangement as per Fig. 15 is intended for poorer gases, where both air and gas must be preheated. Fig. 16 illustrates the application of the inven-



FIGS. 7 TO 10.—ELECTRODE CONSTRUCTION—ELECTROGALVANIZING PROCESS

tion to the heating of blast for blast furnaces. With these purposes in mind the drawings can be easily understood. The letter *c* always designates a blower or compressor for fuel gas, *w* one for air and *x* an exhaustor for waste gases. (1,062,122, May 20, 1913.)

Making Pig Iron from Steel Scrap.—In view of the fact that on the Pacific Coast the selling price of pig iron during the past 10 years has ranged from \$20 to \$32 per ton, a simple

method of converting steel scrap back into pig iron from which it was made may be of interest to these districts where scrap, fuel oil and carbon are plentiful. Mr. **Horace W. Lash** of Cleveland, Ohio, melts for this purpose scrap, carbon, and silicon in any suitable type of furnace, preferably in a reverberatory furnace. The melt is drawn off in the usual

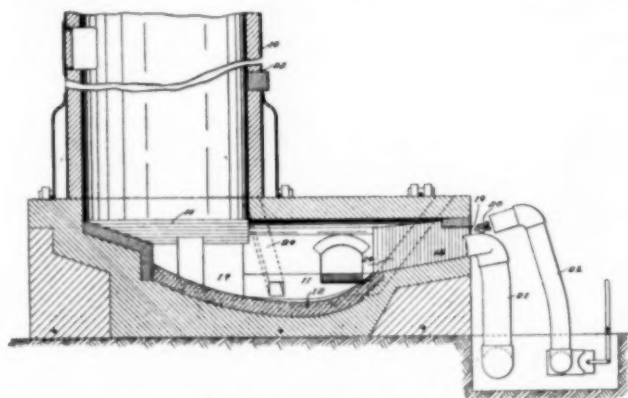


FIG. 11—CUPOLA DESIGN

manner and cast into pigs. It is more economical to obtain the silicon required from that contained in the mixture than to add ferrosilicon or siliceous pig iron. The major portion of the carbon charged should be placed in or near the bottom

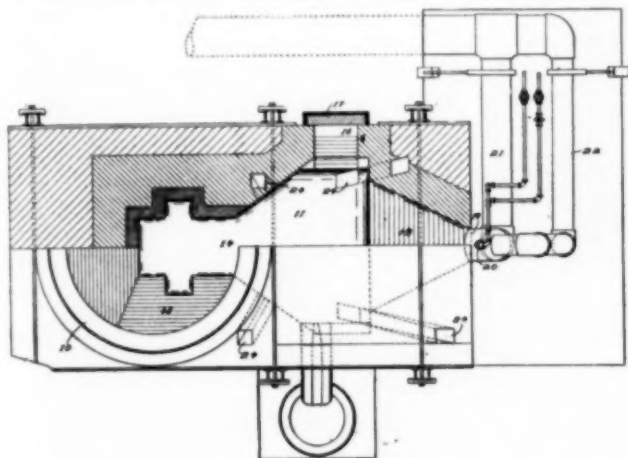


FIG. 12—CUPOLA DESIGN

of the furnace, where it is protected from the oxidizing flame. (1,061,189, May 6, 1913.)

Method of Stripping Sheets.—Mr. Joseph McFetridge of Vandergrift, Pa., describes a method of stripping defective galvanized sheets in preparing them for regalvanizing and

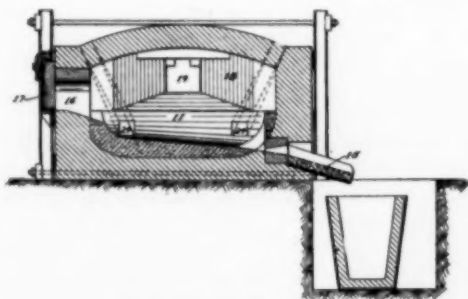
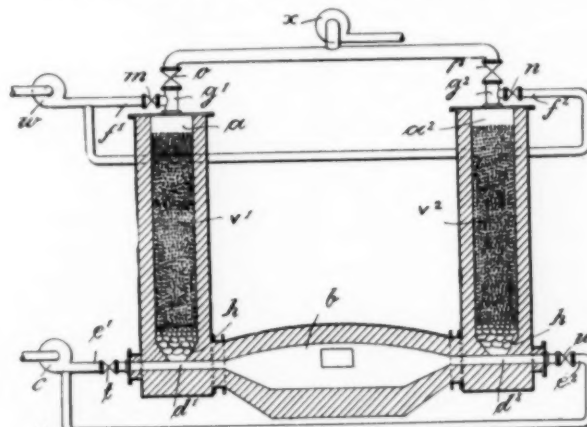


FIG. 13—CUPOLA DESIGN

recovering the removed zinc. Heretofore the practice had been to place the sheets in a solution of ferrous salts and free acid and to keep them in this bath until the zinc and zinc-iron alloy is dissolved and the surface of the base material uncovered. This results in a moderately dilute solution of zinc salts high in ferrous salts and the solution has no commercial value.

The present inventor, instead, provides two baths, in the first of which he removes the greater part of the zinc and zinc-iron alloy. In the second bath the operation is completed. The first bath contains a zinc salt and from 2 to 3 per cent free acid. After it has been neutralized to an acid content of between $\frac{1}{2}$ and 1 per cent portions of the first solution



FIGS. 14 AND 15—REGENERATOR DESIGN

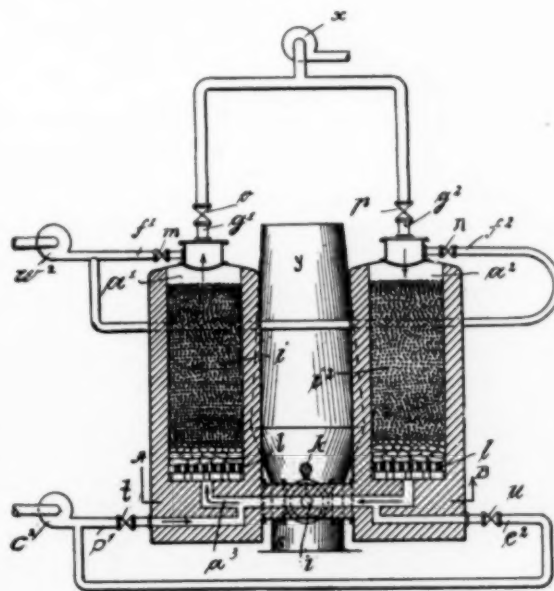


FIG. 16—HOT-BLAST STOVE

are removed to form the second bath and acid is added to the first bath to restore its original strength. The solution of the second bath, which is distributed in two tanks, can be elevated into a container from which it trickles or flows downwardly through a tower packed with quartz. The lower end of the tower is provided with an inlet through which a supply

of oxidizing gas, such as chlorine gas, can rise upwardly through the quartz and oxidize the iron into the ferric form. In special precipitating tanks the liquor is treated with zinc carbonate. The pure zinc solution is decanted and filtered and finally delivered into storage tanks. It can thus be utilized commercially and is not allowed to go to waste. (1,063,054, May 27, 1913.)

Various Electrochemical Processes

Production of Ammonium Compounds.—Dr. Charles P. Steinmetz of the General Electric Company has devised a process of producing ammonium compounds by passing a mixture of steam and air or nitrogen through an electric arc. According to the proportion of the gases employed varying

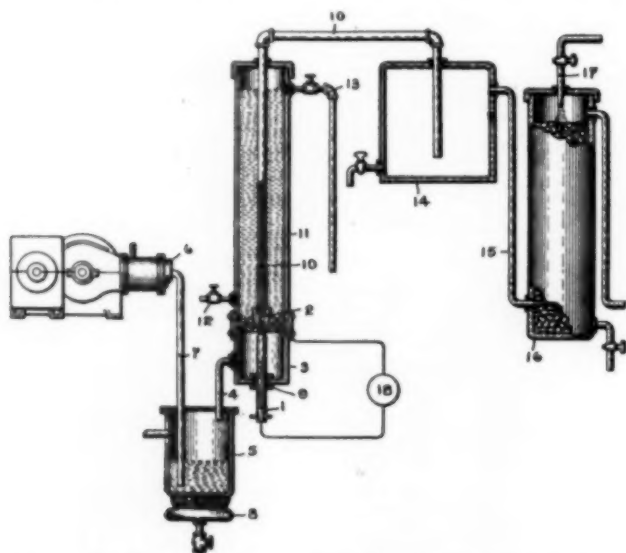


FIG. 17—PRODUCTION OF AMMONIUM COMPOUNDS AND NITRIC AND NITROUS ACIDS

proportions of ammonia and nitrous or nitric acids are formed. The proportion of nitrate to nitrite varies with the relative amount of oxygen and the length of time the oxygen is in contact with the compounds which are formed. The process is best described by following the apparatus shown in Fig. 17: The air, or nitrogen, supplied by a pump 6 carries with it steam from the tank 5, the amount being regulated by gas burner 8. The mixture of air and steam passes into the pressure chamber 3, and from thence through an arc formed between electrodes 1 and 2. The products of the reaction are cooled below the temperature at which the reverse reaction can take place by contact with the cooled walls of the tube 10. In the reaction chamber 14 oxygen combines with the nitric oxide to form nitric dioxide, which with water gives nitric and nitrous acids. These acids in turn combine with ammonia to form ammonium nitrate and nitrite. Some of the ammonium nitrite formed by a combination of the ammonia and the nitrous acid in the tube 10 and in the chamber 14 is oxidized to form ammonium nitrate. The watery vapor unacted upon is condensed in the chamber 14. The uncombined nitric and nitrous acids, or ammonia, pass over into the absorption tank 16, where they are either dissolved in water to form nitric and nitrous acids, or ammonium hydrate, as the case may be. Uncombined acids combine with the lime or other reaction material to form nitrate or nitrite of calcium or of other metal. (1,062,805, May 27, 1913.)

Electric Furnace for the Continuous Manufacture of Glass.—The old problem of melting glass in the electric furnace is taken up again by Mr. Marius Sauvageon of Colombes, France. In pursuit of his older patents of 1910 he describes a furnace made up of a melting and refining division and a working chamber. Both are separated from each other by the floating dam 12 shown in the vertical section, Fig. 18, and in the horizontal section, Fig. 19. Of course, a furnace

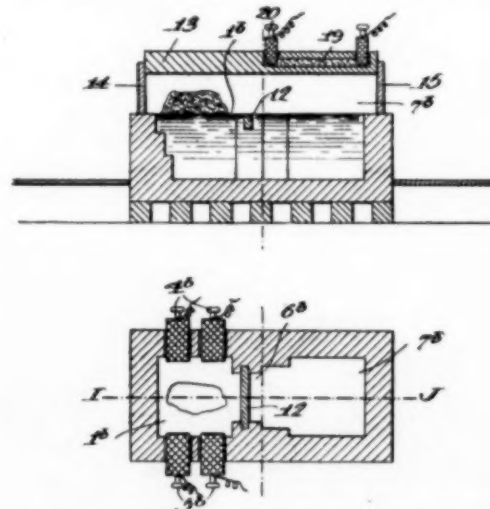
may be built with a melting chamber in the center and refining chambers at both sides. The heating current is supplied at low voltage through electrodes, 4b and 5b, mounted in two opposite sidewalls of the melting chamber. The path of the current being across the chamber is correspondingly short. The furnace is started with a mass of molten glass poured into the melting chamber, or by the aid of an arc. If necessary, the refining chamber can be kept warm by indirect resistance heating by means of register 19. (1,062,362, May 20, 1913.)

Process of Producing Elementary Silicon and By-Products.—Mr. Florentine J. Machalske of Philadelphia, Pa., claims the following peculiar process of producing metallic silicon from silicates. Carbon is mixed with the siliceous compound in molecular proportion to such an extent that there is but sufficient carbon to combine with the oxygen of the silica only. If this mixture is treated in a commercial electric furnace, preferably of the resistance type, the silicon is supposed to be reduced to the elementary state and the other component part of the silicate is not decomposed. A furnace of about 100 kw with a variance of voltage from 20-50 at 2000-5000 amperes is used. To start the reaction about 1 per cent of sodium chloride and sawdust each are mixed with the furnace charge. The process is described in detail for anhydrous kaolin according to the equation:



It is said it can also be used for ores such as tungsten silicate when metallic silicon is obtained with tungstous oxides as by-product. In order to separate the products after fusion in the furnace they are directly subjected to centrifugal action while allowing the current to pass at a voltage somewhat less than that used during the electrothermic fusion. (1,062,982, May 27, 1913.)

Purifying Carbon for Carbon Filaments.—Dr. Jean Billiter of Vienna, Austria, known by his research work on alkali electrolysis, sets forth that the falling to dust of the ordinary carbon filament in lamps is mainly caused by impurities which are contained in all known carbon or graphite filaments. Almost all such impurities will assume a gaseous form at and above 2000 deg. Centigrade and these gases will gradually disintegrate the filament, even if the latter has been



FIGS. 18 AND 19—ELECTRIC GLASS FURNACE

preliminarily heated up to 3000 deg. Centigrade. The filaments made from the purified carbon of Dr. Billiter's invention contain less than 0.1 per cent. impurities and at least 94 per cent of the carbon in the form of graphite. The essential feature of his purification process is to transfer the carbon or graphite, which has been purified as highly as possible, into a colloidal form (in which they will remain in suspension for days or weeks without precipitating). It is then separated by suction or "ultra filtration" from a great part of impurities which

do not assume a colloidal form. To produce the colloid the material is, for instance, heated by a current until it disintegrates to dust. This process must generally be repeated and is aided by a treatment with fluorine. Thus the carbon filament may be anodically polarized in hydrofluoric acid. (1,062,431, May 20, 1913.)

Synopsis of Recent Chemical and Metallurgical Literature

Lead and Zinc

Electrolytic Lead Refining.—In a paper read before the Western Branch of the Canadian Mining Institute, MR. JOHN F. MILLER, superintendent of the electrolytic lead refinery of the Consolidated Mining & Smelting Co., of Trail, B. C., described the process in use at that place.

Base lead bullion produced in blast furnaces contains about 97 per cent lead and 3 per cent of gold, silver, antimony, arsenic, copper, zinc and traces of other metals. It is cast into anode bars weighing about 400 lb. each and loaded into anode cars containing 10 anodes each. Twenty such cars are loaded onto a railway car and transported to the refinery. Here an electric crane unloads the anode cars and carries 20 anodes at a time to the tank room. The tanks are 30 in. wide, 44 in. deep and 7 ft. 4 in. long, holding 20 anodes spaced 4½ in. centers. Cathode starting sheets of pure lead are placed between the anodes. The electrolyte contains 12 per cent hydrofluosilicic acid and 6 per cent lead fluosilicate. This is circulated down the cascade of tanks at the rate of 35 cu. ft. per hour. A continuous electric current is passed for five days, at the end of which time the cathodes are removed and replaced with another set of starting sheets. When the second set of cathodes is formed and removed, the anode scrap amounts to about 15 per cent of the original anode weight and is removed to a melting pot to be again cast into anodes. The refined anodes are melted and cast into molds of 5, 10, 100 or 200 lb. weight, according to requirements.

The anode slime containing gold, silver, copper, antimony and arsenic, is washed, dried, melted and cast into doré bars, the impurities being oxidized and slagged. The doré bars are parted by sulphuric acid; the gold sludge is collected and melted, producing gold bars 995 fine; the silver sulphate solution is precipitated by boiling with copper, producing metallic silver and copper sulphate. The resulting silver bars are 999 fine. The copper sulphate solution is crystallized and the resulting blue vitriol sold for use in agricultural and horticultural industries. Formerly the antimony and arsenic contained in the slime were recovered, but owing to the lower percentage of these metals now in the slime and the lower market price, their recovery has been abandoned. The plant is so arranged that the recovery of antimony can be resumed when conditions warrant.

The method adopted for recovery of antimony is to boil the slime with sodium polysulphide which extracts from 80 to 90 per cent of the antimony and 50 per cent of the arsenic. The solution is filtered and electrolyzed in iron tanks containing lead sheet anodes and steel sheet cathodes, using a cathode density of 8 amp per square foot, with a normal voltage of 1.5 per tank. The antimony forms hard, dense deposits on the steel cathodes and is removed from time to time. It contains about 2 per cent arsenic which is removed by alkali fluxes when the metal is melted for casting. The electrolyte is concentrated in steam-coil evaporators and used again, with the addition of a little more sulphur for the treatment of a new batch of slime.

After treatment for removal of antimony the slime is treated with 10 per cent H₂SO₄ to remove copper and silver which are then recovered as blue vitriol and metallic silver. The residue is then melted in an oxidizing atmosphere with a little coal or silica to break up PoSO₄, resulting in doré bullion which is then parted and treated as described above.

Returning to the refined lead: it contains no arsenic or

bismuth and the following percentages of other metals; zinc, 0.0005; silver, 0.0013; copper, 0.00075; iron, 0.00075; tin, 0.0001; antimony, 0.0028; lead, 99.9938.

The electrolyte contains an addition agent in the form of glue, which is added in the proportion of ½ to 1 lb. per ton of lead produced. While the action of the glue is not wholly understood, it prevents the formation of soft, spongy and incoherent deposits of cathode lead. In fact, it would be impossible to operate without it, as the tanks would all become short-circuited.

Early Example of Blast-Roasting.—A primitive form of the application of modern blast-roasting of sulphide ores is described by MR. H. VASSILIADI in *Bulletin* No. 104, Inst. Min. & Met. In 1895 the author had charge of the metallurgical department of the Balia mines in Asia Minor. The ore was complex, containing galena, blende and pyrite in a calcareous gangue. A notable proportion of the lead saved on Harz jigs and tables was in the form of middlings, assaying as follows: Lead, 19.15 per cent; silica, 7.47; iron, 23.67; lime, 0.80; zinc, 6.59; sulphur, 35.13.

These middlings were roasted and agglomerated in so-called Pelatan furnaces, introduced from Laurium, Greece. Each furnace was 2.9 m long, 0.9 m deep and 1 m high. The sides, back and bottom were cast iron, but the front was water-jacketed sheet iron, removable to facilitate the subsequent manipulation of the roasted cake. The furnaces were built in pairs with a common flue. A hinged lid completed the arrangement. A foot from the bottom was a cast-iron grate of the same dimensions as the horizontal section of the furnace. Three rockers in the form of an arc of a circle were bolted to the bottom of the grate and rested directly on the bottom of the furnace. Air could be blown under the grate through an opening in the floor connecting with an air main.

After the grate and front had been placed in position and all joints luted with clay, a layer of twigs and brush was placed on the grate and over this a 6-in. layer of ore. The wood was lighted and a low-pressure blast, about 5 cm water, was applied. As soon as the ore had ignited more damped middlings were added until the furnace was full. The blast was increased as required until it reached a maximum of 15 to 20 cm water pressure. When fumes ceased issuing from the furnace and the contents had cooled the front was removed and the charge dumped from the grate. It was broken with bars and sledges and the fine material used as the lowest layer of the next charge, while the balance was fed to the blast furnace.

Later Maletra furnaces were added to give the middlings a preliminary roast and thus produce a material containing only about 10 per cent sulphur for final agglomeration in the Pelatan furnaces. This worked very satisfactorily and greatly increased the capacity of the agglomerating plant. The time for agglomeration was reduced from fifteen or eighteen hours to eight, and the troublesome fusion and agglomeration without previous desulphurizing were avoided. The following figures show the improvement in the final product made by preliminary desulphurizing.

	Per cent Pelatan Product	Per cent Maletra-Pelatan Product
Lead	20.25	27.60
Silica	14.50	11.34
Sulphur	17.05	2.20
Iron	27.09	36.00
Lime	1.10	1.20

The plant described has long been discarded but is interesting as an early example of blast-roasting.

Electric Zinc Smelting and Chemical Manufacturing.—From the *Australian Mining Standard*, May 22, 1913, we learn that the Sulphide Corporation has constructed a plant at Cockle Creek, New South Wales, for the electric smelting of zinc ores, combined with the manufacture of sulphuric acid and superphosphate. The plant was supposed to be ready for operation last June but no later information is at hand.

Prior to erecting the 500-hp electric furnace at Cockle Creek the Sulphide Corporation had made extensive experiments on ore shipped to Sweden where the metallurgical results were apparently satisfactory. The power problem was, however, entirely different in Australia and the results obtained in Sweden could not be taken as indicative of what could be done at home. It has been decided to see whether power cannot be cheaply produced by burning gas from Mond producers, recovering ammonium sulphate as a by-product and thus reduce the cost of power. In order to utilize the sulphur now wasted from the roasting furnaces a chamber acid plant is erected to make sulphuric acid, part of which will be used to fix the ammonia from the producer gas and the balance for the manufacture of superphosphate. A large plant for this latter process is in course of erection. By this combination of metallurgical and chemical engineering it is hoped that an economical plant will result.

Principles of Mill Design

"It is vitally important to plan a mill before drawing the plans. This may seem a paradoxical aphorism, but it is not. The most thorough thinking must be done when nothing yet exists. It is necessary to decide the type of mill best suited for the treatment of the ore, where to build it, how to dispose of the general arrangement of the plant and even to investigate carefully whether there is any need for a mill at all."

With the foregoing introductory paragraph, Mr. GELASIO CAETANI opens an interesting discussion of the general principles of mill design, in the June, 1913, issue of the *Mining Magazine*.

The importance of preliminary metallurgical tests is first emphasized. Formerly it was common practice to build a mill of standard design and then adapt it to the special requirements of the ore as determined in operation. This is no longer countenanced and the larger companies even construct experimental mills of considerable capacity in order to test the ore, while smaller operators should always avail themselves of the facilities offered by testing plants which can be found in all large cities.

After settling the metallurgical requirements it becomes necessary to choose the site and determine the general arrangement of the plant. Too much time and effort cannot be spent on the design of the mill for it is so easy to shift the plant around at this stage of the game. "One day spent in thinking may save a fortune in operating expenses." After calling attention to the danger of falling in love with one's own plans the author states that he believes all plans should be drawn three times: first to crystallize the idea, second to determine the structural defects, and third to perfect the solution of the problem. The idea is the main thing—if the idea is wrong the plan is useless and can be destroyed.

In designing an ore-dressing mill the author believes that it is economy, especially in large projects, to separate the crushing and treatment plants. If the crushing department is in the same building as the ore-dressing department, ore bins and some of the heavy machinery must be placed on top of the mill, thus requiring heavy substructures and reducing the capacity of the bins. Further, the handling of dry ore is cheaper than the handling of wet ore, and as much as possible of the preliminary preparation should be dry. This brings up the necessity of keeping dust-forming operations away from the ore-dressing plant and suggests separate buildings for the two processes. Carrying the idea further, stamps might well be in a separate building and amalgamation also could be conducted as a separate department, after the practice in South Africa.

The segregation of a plant in separate buildings is not wholly advantageous; there are great advantages in having as much as possible of the machinery under one roof. The Miami mill is cited as an example of fine construction of this type.

Mr. Caetani also touches on the aesthetic principles in mill construction, calling attention to the desirability of maintaining harmony and proportion in the design. "A thing that is ex-

cellently adapted to the purpose for which it was designed, is beautiful; therefore proportions, general arrangement, facility and economy of operations, good illumination, and so forth, are all features that contribute toward efficiency and so toward beauty."

In considering materials of construction, the author calls attention to the use of concrete in all masonry work, and especially in foundations for buildings and machinery. Floors, jigs, bins, settling tanks, etc., also have been constructed of this material, but its use in this connection is not desirable if many changes are to be made. Concrete construction has long life, but is not plastic, easily moved or modified, and, therefore, should not be used unless the work is of a permanent nature.

Steel is being more widely used for structures, and has advantages in not warping or sagging, and in the matter of fire protection. Nevertheless wood is the more common material of construction, owing to the fact that it can be framed and erected so much easier than steel. It should be preferred in small plants, or in places where changes in construction are likely. A combination of steel and wood construction offers many advantages in designing elegant structures.

The author believes that a hillside is generally the best site that can be chosen for a mill, as the ore can flow by gravity from one department to another. "It is a mistake, however, to believe that no hillside mills require any re-elevation of the ore." Where re-elevation becomes necessary, it is better to make one re-elevation to a considerable height than several at different times and places in the mill. Operations should be concentrated, not only with regard to pumps and elevators, but with other machinery in the mill. Machines that have an organic part in the mill operation should be in duplicate, if possible, and hence it becomes necessary to have as few of these as possible. All machines of one kind should be arranged on one floor, if possible, as this arrangement reduces labor and increases efficiency. Main alley-ways for the handling of large pieces of machinery, and cranes to serve lines of heavy machines are almost indispensable. Classifiers, launders, tanks, and other containers that are likely to overflow at some time or other should not be placed over machinery that will be damaged by such overflow of pulp or water.

One of the most important problems to be determined is the circulating system. The tonnages of the various products and materials must be carefully calculated, and ample provision made for the extreme quantity that may have to be handled. The normal load must be taken as the minimum load, and the system must be made very elastic to take care of unusual conditions. The mill feed may fluctuate considerably, and in closed circuits the volume of material to be handled may suddenly be greatly increased due to the inefficient performance of some machine. Thus trommels and rolls may accumulate an idle circulation of ore which overloads both and causes inefficient results. This is a condition difficult to remedy, and it should not be allowed to occur, or the system should be arranged to relieve temporarily the load on the machines. Elasticity in design thus becomes a very important feature.

The Consolidated Mercur Gold Mines Co., Mercur, Utah, recently ceased operations after a career full of profit and progress. Accompanying checks for a 3-cent dividend, the company sent the following announcement of the closing scenes at the mine. "The last skip of ore was hoisted at 8.40 a. m. Sunday, March 30, 1913, and the Mercur mine was at an end. An hour before, Joe Sullivan, one of our oldest miners, loaded the last car in the mine. The car was decorated with bunting and flags, attached to the last train, hauled out by the motor, and dumped in the Mercur pockets. As the last skip was being hoisted, the flag was raised on the mill, the whistles were blown for one hour, the church bell, school bell and fire bells were rung and the famous old producer passed into history with due ceremony."

The production of crude barytes in the U. S. in 1912, according to J. M. Hill, of the U. S. Geological Survey, was 37,478 short tons, valued \$153,313.

Notes on Chemistry and Metallurgy in Great Britain

(From Our Special Correspondent.)

Iron and Steel Institute

In the continuation of the discussion on the paper of Dr. W. Rosenhain and Mr. J. C. Humfrey on the "Tenacity and Fracture of Soft Steel," the first part of which was reported in the last issue, Professor J. O. Arnold went on to say that while he sincerely congratulated the authors upon a most valuable research, it appeared that they found out that there was something unsatisfactory in connection with their electrolytic iron and took for their experiments a tin-plate steel containing about 0.11 per cent carbon and 0.4 manganese. The authors said that the curves of absorption and recalescence were taken with a special apparatus, and that uniform rates of heating and cooling were maintained, while the observations were taken by means of a thermocouple and the delicate and accurate potentiometer of their laboratory. But the curve shown on the screen hardly confirmed the optimistic view of the capabilities of their apparatus expounded by the authors. The adjoining curve depicted an observation typical of many observations by himself and Mr. T. Swinden with the recalescence installation at Sheffield University in 1906, from a steel containing about 0.22 per cent carbon and 0.05 per cent manganese.

Nevertheless the authors' curve did in a way show the fourth recalescence of steel, the discovery of which he had announced to the Chemical Section of the British Association in 1910. He had added the dotted lines to the authors' curve to show this. But Dr. Rosenhain had not managed to split up the Ar₂ into its constituent peaks, and appeared to be laboring under the curious misapprehension that the fourth recalescence of steel was the second peak of Ar₂, which he, nevertheless, scornfully described as a "wobble." This led him (the speaker) to ask the conundrum, "When is a wobble not a wobble?" And the answer was, "When it occurs regularly in scores of observations." The fourth recalescence was shown in the right-hand curve recorded as a prolonged evolution of heat, which kept the observed curve between Ar₃ and Ar₁, to the right of the dotted radiation line. This evolution of heat was due to the falling out, after Ar₃, of the hardenite previously existing in solid solution in the gamma range of temperature.

In 1909 the authors stated as a definite fact that beta iron was sufficiently hard to show no micrographic evidence of plastic strain under a stress sufficient to disrupt the alpha iron, and this in spite of the hardening effect of the lower temperature. In 1913, after making elaborate experiments, they proved that beta iron in spite of that same hardening influence gave the minimum stress recorded in all the three ranges of temperature; and in the middle of the beta range gave the startling elongation of nearly 13 per cent. Then they said in effect that their second research to a considerable extent confirmed the conclusions of the first, but admitted that certain modifications might be necessary.

Modifications, indeed! If in practice they got a steel casting which consisted mostly of gas blow-holes surrounded by steel, they "modified" that casting by throwing it on the scrap-heap. It was his opinion that the authors' unwisely veiled apologia subconsciously trifled with the institution.

There was abundant evidence in the paper that the authors were quite at a loss to account for the unexpected fact that in the beta range the iron seemed to be so soft as to give minimum stress and maximum strain: and, therefore, on the erroneous supposition that they were dealing with results obtained from chemically pure iron and not from their dead mild steel, proceeded to elaborate a theory ascribing the disconcerting fact to the influences of the dimensions of the crystals and of a hypothetical amorphous cement existing between those crystals.

Their valuable observations provisionally showed that the

mechanical hardness of iron in the lower gamma, the beta and the higher alpha ranges of temperature was approximately inversely proportional to the temperature, and was not in any way connected with the Ar₃ and Ar₂ points; but this, the real explanation, had completely escaped their attention. The slide on the screen showed the condition of the micro-chemical constitution of the authors' specimens of mild steel, and this was shown diagrammatically with substantial accuracy in three typical examples. In the gamma range at 924 deg. C. the 12 per cent of slightly manganiferous hardenite (the existence of which had been entirely ignored by the authors) was evenly diffused in solid solution throughout the masses, thus hardening the iron in spite of the softening effect of a high temperature. After the Ar₃ point, coming down the beta range to 836 deg. C., the hardenite had to a great extent fallen out of solution and evolved the fourth recalescence, leaving a ground mass of bright blood-red iron surrounding the masses of ferritic hardenite which constituted about 25 per cent of the area. The tensile strength of the mass now fell and the elongation increased, because stress was now mainly applied to iron without hardenite. Then under the hardening influence of lower temperature in the alpha range the stress increased again and the elongation became lower.

He sincerely thanked the authors for their able experimental proof of the accuracy of the teaching of the physical chemistry of mild steel which for so long had been carried out at Sheffield University. Although the authors maintained that the question of hard beta iron was still open he submitted that it was closed for ever, and that hard beta iron was as dead as the Doges. Looking back for some twenty years and reviewing the evil effect upon the true scientific progress of our knowledge of the physical chemistry of steel brought about by the acres of pseudo-scientific garbage written about the beta iron hypothesis he was inclined to use strong language; but he remembered that this hypothesis was now among the things that had gone, and he would therefore only say of the beta iron theory, "Peace to its ashes."

In the Proceedings of the Royal Society, A. Vol. 83, page 208, in a paper by Messrs. Rosenhain and Humfrey, November 25th, 1909, the statement was made:—"We have the striking fact that, as a result of the α/β transformation, the iron becomes stronger and harder in spite of the tendency of increasing temperatures to reverse this relation. The fact that in the β iron, near the transition temperature, there are very few signs of slip or disturbance of any kind further shows that not only has this material a greater tensile strength, but that it is also harder and has undergone practically no plastic deformation at all under a stress sufficient to rupture an equal section of a iron.

In the Proceedings of the Iron and Steel Institute, in the paper read by Messrs. Rosenhain and Humfrey, on May 2nd, 1913, the following figures were given in Table IV. Rate of extension 0.0005 in. per second per in.

Temp. °.	Range.	Max. stress	
		lb. per sq. in.	Elongation.
924	Gamma	5,350	72
836	Beta	2,780	130
686	Alpha	7,500	72

"In comparing these conclusions with the deductions drawn by the present authors from their earlier experiments described in the paper referred to above, it will be seen that, although in general terms the quantitative measurements confirm the result of the earlier qualitative work, they yet required some modification of the earlier conclusions."

Professor H. C. H. Carpenter submitted that the paper was tantamount to an admission that the authors' interpretation of their paper before the Royal Society was wrong. In criticising the table of data for stresses, he said that the evidence of change in passing from alpha to beta consisted of results several hundreds per cent outside the range of the experimental error: and, with regard to the bottom curve—when the rate of stressing was very slow—the authors had actually had to invent the discontinuity drawn there. If the curve had

been drawn through the ascertained points it would have been quite smooth throughout the beta range. They seemed to be quite blind to the evidence of this fact, and were so wedded to the beta theory that they must actually invent that kink in the curve. This was entirely unjustifiable; and they should have paused before drawing such a conclusion on such microscopically slender evidence. The authors found it difficult to reconcile this "discontinuity" with Benedicks' theory which regards beta iron as a solution of gamma iron and alpha iron; but they were not dealing with pure iron, and he maintained that their results were exactly in accordance with what might be expected if Benedicks' theory were true.

Sir Robert Hadfield, after explaining why he had abandoned the allotropic theory, remarked that, although the authors said they regarded their earlier experiments as of a preliminary character, it was unfortunate that others had not been allowed to take this view, and the authors' previous results had been quoted repeatedly as proof of the existence of hard beta iron. They had, in fact, lately been the basis of the beta theory, and it seemed to him that the authors could not persist in believing that such a form of iron exists. They had said that the heat relief developed in the beta range is identical with the alpha structure found by etching the cold specimen, and this fact seemed to prove that the authors' alpha and beta iron were the same thing, and he thought the authors should be satisfied that their previous theories were not tenable.

Mr. J. C. Humfrey, in replying, said that Professor Carpenter had quoted figures out of the tables at the end of the paper with reference to the beta change point. As a rule it was very unfair to quote figures of one result in a research like this, which included some 200 experiments. It was more important to see the actual shape of the curve than to select one or two points here and there.

Dr. Walter Rosenhain in his reply said the discussion had been rather extraordinary. First, there had been an impassioned oration from his Sheffield friend, which he might divide into three parts—first, complimentary, which he appreciated highly; secondly, vituperative, which he neglected; and, thirdly, and this only a small proportion, definite argument, which he proposed to deal with. Professor Arnold had sinned in even a worse degree than Professor Carpenter, in picking out isolated sentences in a most misleading way, and endeavoring to hold up the authors to derision; and he would ask his audience to read their paper on its merits, and also the remarks of Professor Arnold on their merits, and he would be content with their judgment. A serious argument Professor Arnold had made was the suggestion that the authors had ignored the influence of 0.1 per cent of carbon, or, at all events, that they underrated it. That might be possible, but they found as a matter of fact in their experiments on electrolytic iron just the same kind of changes of strength and structure as in the particular variety of steel described in the paper, and this seemed to justify the tacit assumption that the influence of 0.1 per cent of carbon at the temperatures in question was very small. With regard to Professor Carpenter's remarks, he considered that his defense of the Benedicks' theory was overdone; and when he suggested that the authors had invented the discontinuity his criticism had gone too far altogether. If they looked at the points plotted on the curve they would see that it was not possible to really get rid of all this discontinuity at A₂ except at the lower curve, and then they would have to invent continuity, not discontinuity. Many other points which had been raised he would reserve and deal with in writing.

The last paper taken was on "The Critical Ranges of Pure Iron" by Professor H. C. H. Carpenter, whose conclusions were that (1) A₂ as an independent critical point or range does not exist. (2) A₂ as a critical point or range cannot be detected on a heating curve when the bulk of the dissolved hydrogen has been removed. There are traces of a retardation in the rate of heating spread over a considerable temperature interval, which might be expected to include A₂

within its limits if it existed. (3) Ar₂ (which is evident on all the cooling curves taken) is the temperature at which gamma iron ceases to be merely metastable and becomes unstable. (4) Of the two values obtained for Ac₃—viz.: 926 deg. and 916 deg.—the latter is the more probable, because it corresponds within 1 deg. to the temperature at which the iron recrystallizes on heating. (5) The mean temperature of the Ar₃ peak is 888 deg. C.

The discussion was opened by Dr. Rosenhain, who said that he could not accept Benedicks' theory—much as he would like to—because it was a simplification. His experience of heating and cooling curves of electrolytic iron and nearly all carbon alloys of iron agreed with Professor Carpenter's and Dr. Arnold's, and the whole question was how much had Ar₂ to do with the gases in the steel?

Sir Robert Hadfield referred to the experiments carried out by O'Shea with electrolytic iron because it was that material which first led him to alter his conviction against the existence of beta iron. Professor Roberts Austen was then claiming that electrolytic iron proved the existence of beta adamantine formation, but when he (the speaker) obtained specimens he could not agree with that conclusion and entirely abandoned any belief in allotropic and adamantine formation of iron. In conclusion he said that the Institute was that morning making history in the Metallurgical World, and was now starting a theory which would do away with the great waste of time they had experienced in the past, and in future they would examine steel on a new basis and work on the behavior and properties of crystalline structures. The old theory had now been proved to be extinct.

Engineering Imports and Exports

The returns issued by the Board of Trade for the five months ended on the 31st may compare very favorably with the figures for the corresponding period of 1912—the only decrease being a small one in electrical goods. Imports of iron and steel, including manufactures, amounted to £6,412,419, an increase of £1,657,547; and exports totaled £23,381,966, an increase of £5,254,172. Imports of other metals, including manufactures, went up to £13,906,409, an increase of £1,855,268; while exports reached £5,806,333, an improvement of £1,161,676. Electrical goods were imported to the value of £624,868, a decrease of £6,091; but exports rose to £2,381,357, showing an increase of £636,603. In machinery the imports were £3,162,493, a rise of £278,970; and exports amounted to £15,190,633, an increase of £2,060,971. Imports of new ships are valued at £13,922, and the exports at £3,379,469, showing increases of £675 and £1,051,601. The figures for the month of May alone also indicate a satisfactory state of trade, and exhibit increases in all classes except imports of machinery.

Market Prices

June, 1913.

Tin opened £212.10, dropped rapidly to £205.15 (10th), recovered to £209 (13th) and fell again to £203.15 (17th), since when it has been about this level or under, showing £193.10 on the 23rd, and closing at £194.

Copper opened £66.15 and showed unsteadiness, dropping £1 in the first ten days, and has not since recovered, declining to £62.17.6 on 23d, but closed better at £64 to £64.5.

Hematite opened 77/9 and fell away to 73/- on the 13th, which price it has kept to the end of the month.

Scotch Pig opened 66/6, declined to 65/- at mid-month and remains at that figure.

Cleveland opened 60/6 and dropped to 54/6, remaining in the neighborhood of that price and closing at 55/4½d.

Lead opened £20.5, has ruled steady and stronger in the third week, touching £21.5.0 on the 19th, then fell away to £19.15, top price, on the 30th.

"The Solution of the Worst Boiler Problem" is the title of a little recent pamphlet of the Yarnall-Waring Co., Chestnut Hill, Philadelphia, on their "simplex seatless blow-off valve."

	£	s.	d.
Aluminum, per ton.....	90.	0.	0
Alum, lump, loose, per ton.....	6.	0.	0
Antimony, black sulphide powder, per ton.....	20.	0.	0
Borax (crystal), refined, cwt.....	18.	6	
Copper ore, 10 to 25%, unit.....	11/3	11.9	
Copper sulphate, ton.....	22.	5.	0
Carbolic acid, liquid 97-99%, gal.....	1.	4	
Caustic soda, 70%, ton.....	9.12.	6	
Ebonite, rod, per lb.....	4.	6	
Hydrochloric acid, cwt.....	5.	0	
India rubber, Para, fine, lb.....	3.	9	
Mica, in orig. cases, medium, lb.....	3/6 to	6.	0
Petroleum, Russian spot, gal.....	9 1/4		
Quicksilver, bottle (Spanish).....	7.10.	0	
Sal ammoniac, lump, firsts del U. K., ton.....	44.	0.	0
Sulphate of ammonia, f. o. b. Liverpool.....	12.17.	6	
Sulphur, recovered, ton.....	5.	5.	0
Shellac, cwt.....	4.	9.	0
Platinum.....	9.	5.	0
Tin ore, ton.....	130. - 132.	0.	0
Zinc, Vieille Montagne, f. o. b. Antwerp, ton.....	25.17.	6	

Electric Arc Welding

The immense progress which has been made in metallurgical practice in recent years is well illustrated by the various new methods of welding, which have been developed in the last decade or so. Based on very different principles, they all have their own field of usefulness: the process of thermit welding based on the ingenious aluminothermic reaction of Dr. Hans Goldschmidt, the gas welding processes making use of the high temperatures of the oxyhydrogen or the oxyacetylene flame, and finally of the electric arc welding process. Thus it has come that the day has passed when ordinary defects such as shrinkage cracks, blow holes, etc., in expensive castings necessitated the making of another casting, or when a crack in a street car truck or a break in a locomotive frame meant the keeping of the car or locomotive out of service for long periods while a new part was ordered from the builder.

The following article gives details of the electric arc weld-

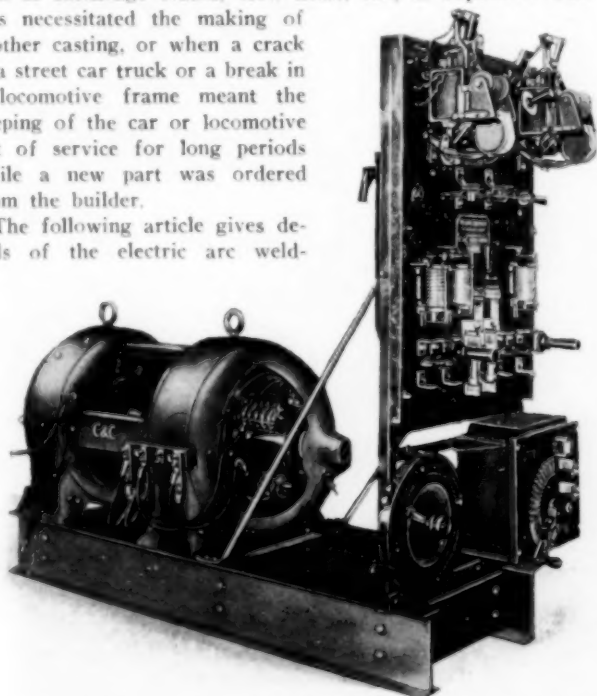


FIG. 1.—PORTABLE 300 AMPERE MULTIPLE UNIT WELDING OUTFIT

ing method and apparatus of the C and C Electric & Manufacturing Company in Garwood, N. J.:

The operation of arc welding is very simple. The usual practice is to connect the work to be repaired with one wire from the electric circuit and to attach the other wire to an electrode handled by the operator. The electrode is first brought into contact with the work, establishing the circuit, then drawn away from the work, forming an arc. The

operator can then move his electrode about over the work and the arc will follow, thus enabling him to concentrate the heat on one spot or spread it over a wide area.

Electric arc welding may be divided into two classes, namely, that requiring the graphite electrode and, secondly, the metallic electrode.

The graphite electrode method requires a potential of 50 to 60 volts at the arc, and a current of 300 amperes or more, and



FIG. 2.—COMBINATION ELECTRODE HOLDER FOR BOTH METALLIC AND GRAPHITE ELECTRODES. HEAD SHIELD.

can be used for all kinds of welding, filling in, building up, cutting, etc. In this method the filling in or welding metal is supplied from an outside source, that is, the operator either has a rod of soft iron or steel or uses scrap metal which the arc reduces to a state of fusion and forms into a homogeneous mass with the part being repaired.

When the metallic electrode is used, the potential at the arc is usually lower, according to the nature of the work. In this process the metallic electrode is consumed, particles of molten metal from the electrode being deposited on the work being repaired. Thus the process has to be interrupted from time to time so that the operator can insert a new electrode. An important use of the metallic electrode is in repairing cracks in large work, for the operator can work on vertical or overhead surfaces. In fact, in locomotive repair shops, it is no uncommon sight to see an operator repairing a crack in a crown sheet from below, all of the metal consumed from the electrode being deposited on the work, thus there is no necessity of the operator stepping aside to dodge drops of molten metal. It is of special importance in using the metallic electrode that a uniform potential be maintained, for slight variations in the voltage disturb the arc and produce an imperfect weld.

From the above, it is evident that each of the two systems has its own application, and, in fact, in practically every shop different classes of work must be done, some demanding the graphite method and some the metallic.

While any source of direct current is suitable for this process of welding, it is at once evident that it would be uneconomical to employ the current from the ordinary supply networks, since for welding a potential of from 10 to 60 volts is required. Further means must be provided to always maintain the proper potential for welding, and finally it is important to protect the line against short circuits, which occur every time when contact is made before the arc is drawn.

All these considerations emphasize the necessity of having a special current supply for welding. Fig. 1 shows a portable 30-ampere multiple-unit welding outfit of the C and C Electric & Manufacturing Company. It consists of a motor (which is either direct- or alternating-current motor, accord-

ing to the system of supply in the plant) coupled to the generator which is of a specially wound variable-voltage direct-current type producing the welding current. This motor-generator set is connected with the switchboard which by the means of a single-throw switch permits the use of either the metallic or graphite electrode, alone, or both at the same time.



FIG. 3.—GRAPHITE ELECTRODE HOLDER. HAND SHIELD

It also contains the protective device, without which in the moment contact is made between the electrode and the work a short circuit would occur, and the generator would burn out or the motor circuit-breaker would be thrown. Thus it would never be possible to get the arc started. This is provided against in the C and C outfit by means of the automatic series relay. This provides that whenever the electric weld-

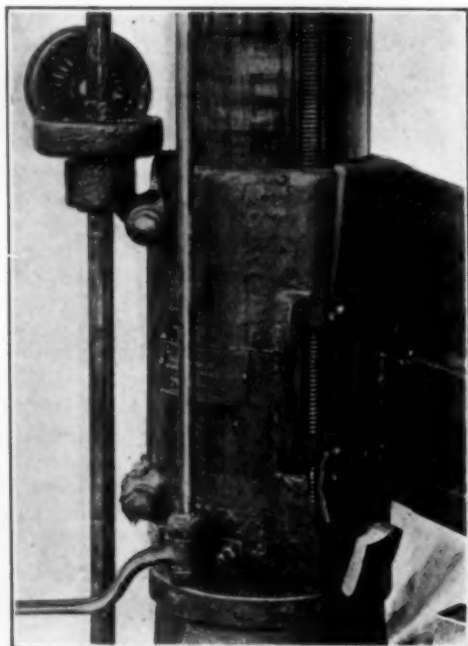


FIG. 4.—CAST IRON HOUSING SUPPORTING ARM OF RADIAL DRILL
BROKEN IN THREE PARTS

ing circuit is broken a resistance is inserted in series with the electrode, and when the electrode is brought into contact with the work only enough current is allowed to pass to form the arc, and the minute that the arc is drawn this resistance is automatically cut out of the circuit and practically the full potential of the welding circuit is applied.

Fig. 3 illustrates an electrode holder adapted to foundry use where heavy cutting is done. It may be used continuously with the graphite electrode without the handle becoming overheated while welding heavy sections or cutting off large risers from steel castings, cutting up scrap, etc.

Fig. 2 shows a combination graphite and metallic electrode for use in connection with all classes of work, the metallic electrode being used for welding cast and malleable iron, brass, copper, aluminium, marine boilers, tanks, cracks in locomotive fire boxes, etc. This holder makes it possible to make repairs in the most inaccessible places and reduces the cost of the same more than 80 per cent. below the older methods employed. A great saving of time is also effected. Pressing the button in the combination electrode holder automatically reverts from graphite to metallic welding and vice versa.

A well-ventilated universal sighting hood of metal (Fig. 2)

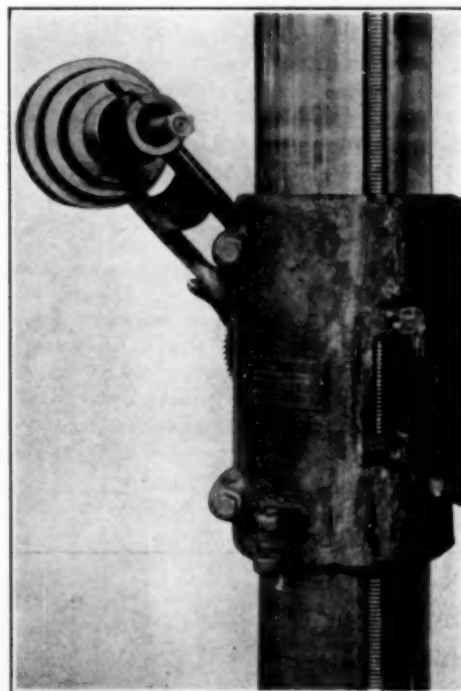


FIG. 5.—SAME AS FIG. 4 AFTER HAVING BEEN WELDED—DRILL
READY FOR SERVICE

is provided, in which glasses of specially blended colors effectually protect the eyes of the operator while welding, leaving both hands free, and thus very materially expediting welding. For short jobs where one hand only is necessary the hand shield, shown in Fig. 3, is generally used.

The figures of cost in Table I. (p. 469) should be of interest, as they are from practice. The column giving costs is figured out at 2 cents per kw. hour for current and 30 cents per hour for labor, but it can readily be figured out what the different operations will cost in any shop by using the figures in columns (1) and (2) and substituting proper costs for labor and power.

In general the same kind of material is used as a filler as the metal to be welded, but much higher efficiency will be obtained if specially prepared electrodes are used for welding various materials. When strength is not a very important factor, a soft iron rod or punchings may be used for welding steel. For repairing cast and malleable iron, a high-silicon iron should be used. Copper, brass, etc., are welded with like materials.

The system is not only applicable to welding, but also to cutting metal parts. As the electric arc produces the hottest flame known, the rapidity with which cutting is accomplished by concentrating the heat at a given point through the graphite electrode is unequalled. This is especially true of large sections which cannot be cut by gas systems.

TABLE I. FIGURES OF COST

	Time.	Average KW. Costs.	
Gear case lugs.....	10 min.	6	\$0.07
Armature shaft (broken) 2".....	60 "	20-30	0.80
Dowel pin holes.....	5-12 "	4-8	0.07
Broken motor cases.....	2½-3½ hrs.	75-90	4.98
Broken lugs on a compressor cover, doors and grease-cup hinges.....	2-5 min.	1-3	0.03
Broken truck frames.....	30-60 "	20-35	0.63
Worn bolt holes in motors and trucks	5-10 "	3-5	0.05
Enlarged and elongated holes in brake levers	2-4 "	1½-3	0.03
Armature shafts, 2", worn in journals	2-3 hrs.	60-90	3.75
Armature shafts, worn in key-ways..	10-15 min.	7-12	0.10
Armature shaft, worn thread.....	20-30 "	10-15	0.24
Air brake armature shafts (broken)..	20-30 "	10-20	0.27
Leaking axle boxes.....	5-15 "	3-7	0.08

The system of arc welding has found introduction in locomotive shops of steam railways, street lighting, repair shops, steel and iron foundries, forge shops, shipbuilding and repair yards, etc. For years it has been the practice to braze the heads in tanks used for storing gas, acetylene, oxygen, etc. This was also the practice with air reservoirs used in connection with air brake apparatus. These heads are now welded in with the C and C method much more rapidly, and at a lower cost. Two heads may be welded on in forty minutes. This system is especially adapted to welding longitudinal seams, thereby cutting down the cost of the shell of tanks and boilers.

Figs. 4 and 5 show one repair illustrating the possibilities of electric welding. In Fig. 4 the cast-iron housing supporting the arm of a radial drill is shown broken in three parts. The casting was removed and welded with graphite electrode. Fig. 5 shows the casting after it had been welded, the drill being ready for service. Ordinary cast iron was used in making this repair. This radial drill has been operated in the shops of the C and C Electric & Manufacturing Company continuously since it was repaired in 1911.

Centrifugal Pumps

Their Proper Selection and Use

By H. De Huff

A well-designed, properly selected and carefully built centrifugal pump is a most satisfactory piece of apparatus, but it is important for its successful operation that it embodies all these qualifications. A centrifugal pump poorly designed, badly constructed or not suited to its requirements can be a most annoying source of trouble.

In the purchase of a centrifugal pump consideration should be first given to the type desired. Whether the pump is to be horizontal or vertical depends almost invariably on the local conditions. As a general thing it is very much better to install a horizontal pump than a vertical pump since easier accessibility to the working parts is possible.

The method of driving the pump is also determined by the available source of power. Where electrical power is obtainable at a low cost, the direct electric motor drive is the ideal method. Where steam is available a steam turbine may solve the problem.

Centrifugal pumps may be divided into two general classes, single-suction and double-suction, determined by the manner in which the impeller takes the water. The former division is further subdivided into single-stage and multiple-stage.

Single-suction, single-stage pumps are generally used where the quantity of water to be handled is comparatively small, or the head to be pumped against is comparatively low.

Double-suction pumps in general are suited for large capacities in low heads, or moderate capacities in high heads where the required head may be secured with one stage. Where the head is such as to require a number of stages, a succession of single suction impellers is generally used, contained in one

case, each impeller delivering its water to the adjacent impeller, thus producing a total head equal to the head produced by one impeller multiplied by the number of impellers.

The number of stages used depends upon the available speed. With the motor speeds ordinarily available running up to 1700 r.p.m., sizes up to 100 hp, a head of 150 ft. per stage is easily obtained, and in fact there are numerous instances where heads as high as 200 ft. are obtained.

One of the most desirable features in a horizontal pump is to have the case divided on a horizontal plane, passing through the axis of the pump, with the suction and discharge connections made to the lower half of the pump case; the two halves of the case being bolted together, removal of the upper half opens up the entire working parts of the pump. This is particularly necessary for multiple-stage pumps, for if the case is not bolted in this manner it is difficult to gain access to the interior of the pump. The larger the pump and the greater the number of stages, the more difficult this becomes.

Bronze impellers are usually most desirable, particularly where heads of 100 ft. and more are used. The mixture of bronze should be a high-grade one, such as to make a tough and very strong metal. The mixture, known as Government bronze, 88 per cent copper, 10 per cent tin and 2 per cent zinc is a very satisfactory metal for general use in centrifugal pump work.

All impellers should be fitted with removable bronze wearing rings where they run close to the pump case so that when wear comes on these parts it is not necessary to replace the entire impeller but merely provide new rings.

The pump shaft should be protected by removable bronze sleeves, so that the liquid pumped does not come in contact with it. These sleeves should extend through the stuffing boxes to prevent cutting of the shaft by the packing which might happen, depending upon the care given the pump.

Bearings should be entirely separate from the stuffing boxes and of the self-oiling type. They should be made with split removable shells babbitted so as to facilitate renewal.

The pump should be connected to its motor by a flexible coupling. The most satisfactory coupling for pump work is the steel pin and rubber bushing type. This allows of sufficient flexibility to care for a slight wear in the bearings and also allows the pump and motor shaft to move slightly endways independently.

From an operating standpoint the important features to be considered are accessibility of all parts and the ease with which the wearing parts can be replaced.

In installing centrifugal pumps they should when practicable be placed so as to reduce the suction lift to a minimum. However, a properly designed centrifugal pump will take care of a very good suction lift without affecting the capacity or efficiency. A lift of 22 ft. is not too much if the suction pipe is comparatively large and there are no foot valves to introduce an excessive amount of friction. Not all centrifugal pumps, however, are capable of operating on such high suction lifts. If not properly designed for such a lift there may be a considerable falling off in the capacity and efficiency of the pump.

Fig. 1 shows a D'Olier double-suction pump for 3000 gal per minute, 110 ft. total head, at 1150 r.p.m., with an efficiency of 76 per cent.

All centrifugal pumps require priming and the case and suction pipe filled with water before they will start pumping, as they have no inherent ability to produce a suction lift unless water is passing through them. However, it is a simple matter to provide for priming. This can be cared for in the following various ways.

First, the pump may be placed below the level of the water from which it draws its supply so that when the suction valve is opened the case is filled.

Second, a foot valve may be placed in the bottom of the suction pipe or a check valve in the suction line below the suction water level so as to retain the water in the pump case and suction pipe. This is very satisfactory provided the de-

sign of the valve is such that it does not cause an excessive loss of head and provided the water is free from floating objects which might get into the valves and prevent them from properly seating. When first starting up the suction pipe must be filled from an outside source of supply.

Third, a steam siphon may be used to exhaust the air. This is efficient for small pumps and where the suction lines are not very large.

Fourth, small pumps may be primed by means of a hand-operated air pump.

Fifth, a separately driven vacuum pump may be installed to exhaust the air from the case and suction pipe. This is an excellent method for priming very large centrifugal pumps.

Centrifugal pumps should be carefully lined up when they are put in service. It is a comparatively easy matter to bend any bed plate by drawing up too hard on the anchor bolts. Attention given to this point will help to insure a smooth-running machine.

For most centrifugal machines a square graphite flax packing will be found satisfactory. This should be cut at an angle of about 30 deg. and the joints staggered. Packing should be first drawn up rather tight, then the glands eased un slightly. A mixture of heavy oil and graphite may be used in stuffing boxes with very good effect.

A properly designed centrifugal pump operates with very little noise and practically no vibration unless air or foreign bodies enter the suction pipe. The presence of air is indicated by a rumbling noise and by a falling off of pressure and capacity.

If for any reason the pump does not appear to deliver its full quantity of water when operating at its rated speed and pressure before entering a complaint to the manufacturer it is advisable for the user to open up the pump case, investigate and see if any foreign objects have become drawn into the

should be left to the pump manufacturer as the speed of it should be determined by the pump requirements and depends also on the available pump patterns and designs. Of course, there are conditions where the motor speed is practically fixed and in this case the pump manufacturer has to make his designs and number of stages conform to the available speed.

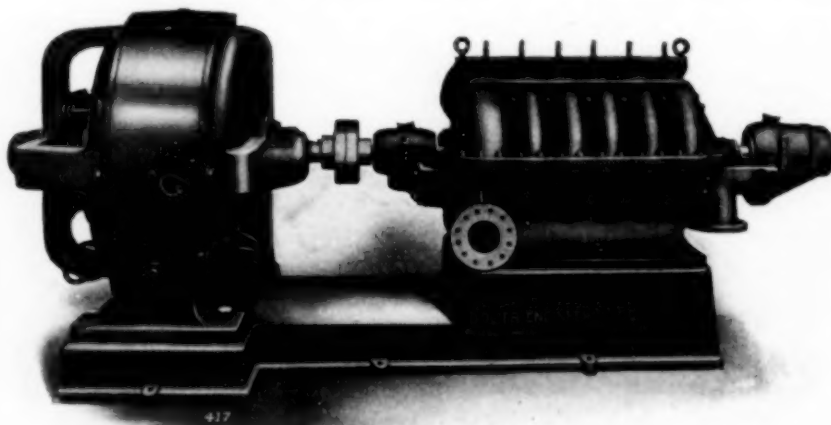


FIG. 2.—SIX-STAGE TURBINE PUMP DIRECT CONNECTED TO MOTOR

The horsepower rating of the driving motor should be sufficiently liberal to allow for a slight excess in capacity and pressure for the pump above contract requirements. It is generally advisable to allow 10 per cent above the power calculated from the given capacity, head and guaranteed efficiency. Consideration should be given also to the pump operating at pressure and capacity other than the rated condition.

By varying his designs the pump manufacturer can adjust more or less his characteristic performances to meet different conditions.

There are occasions when installing a pump when it is desirable to provide for considerable excess capacity at low heads.

In such cases the motor should be of sufficient capacity to care for these conditions without placing a dangerous overload on it.

Centrifugal pumps are in general adapted to a wide range of conditions of service. They can be furnished for practically any capacity desired and for most pressures required commercially. The flow of water from the pump is smooth and entirely free from vibration and pulsation such as is caused by direct-acting pumps.

The centrifugal pump also has the advantage that it cannot damage itself by accidental closing of the discharge valve. The closing of the discharge valve merely results in an increased pressure of from 10 per cent to 40 per cent above the normal operating pressure, with the added fact, also, where the pump is taking its water under suction lift if run sufficiently long with the discharge valve closed it may drop its suction.

In all properly designed centrifugal pumps it should be possible to considerably reduce the pressure below rated conditions without dangerously overloading the driving motor.

Efficiencies obtained in centrifugal pumps depend on the capacity, pressure, speed and the nearness to securing ideal proportions in the impellers and pump case. Efficiencies are

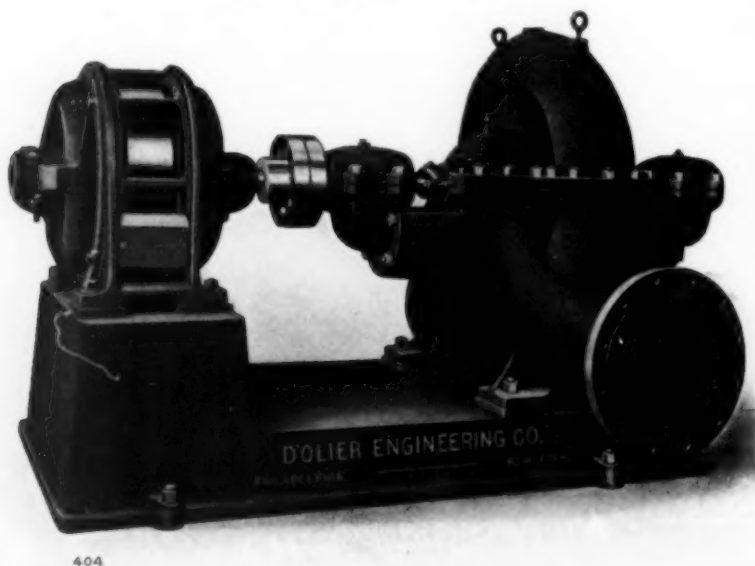


FIG. 1.—DOUBLE SUCTION PUMP FOR 3000 GALLONS PER MINUTE—110 FEET TOTAL HEAD AT 1150 R.P.M.

pump. Several cases have come under the writer's observance where such articles as tin cans, rags, rope, cotton waste and similar objects have been discovered in pumps when complaints have been made that they were not delivering enough water.

Selection of the motor to drive the pump is a matter that

obtained, however, running over 50 per cent in a 100-gal. pump to 85 per cent or even more in a 40-in. centrifugal pump. Very good efficiencies are obtainable in moderate capacity pumps. Under favorable conditions, and if the capacity is, say, 2000 gal. it is possible to obtain an efficiency of 80 per cent, although conservative manufacturers as a rule do not make guarantees so high.

The development of the centrifugal pump during the last decade to its present state of efficiency and wide range of uses reflects great credit upon these several pump manufacturers who, by reason of their appreciation of the possibilities of this type of pump and their enterprise, have brought it to its present position of importance.

The D'Olier centrifugal pump, manufactured by D'Olier Centrifugal Pump & Machine Co., of Philadelphia, two types of which are illustrated in Figs. 1 and 2 in this article, is an excellent example of the advance made in the development of the centrifugal pump.

New Catalog of Laboratory Supplies

Messrs. Eimer & Amend, 205-211 Third Avenue, New York City, have just issued the 1913 edition of their Catalog C of Chemical and Metallurgical Laboratory Supplies and Assayers' Materials. It is a volume of 483 pages, 8 by 10½ inches, bound in red cloth, nicely printed and profusely illustrated. It should be welcome in every scientific, industrial and works laboratory.

A comparison of this latest edition with former editions of the well-known catalog brings out several interesting points, all of which indicate progress. The arrangement of the listed articles is, as before, alphabetical, but the classification has been carried through with greater consequence. For instance, all kinds of tubes are listed under tubes, which should assist in many cases the quick location of an article without referring to the index. The latter, however (17 pages), has wisely been retained.

Of greater interest, however, is a comparison, under the various headings, of the forms of apparatus listed in the present and former editions, since in the latest edition, as far as possible, all apparatus have been omitted which have been superseded by modern types of proven merit. Such a comparison, therefore, brings out forcibly the great advances made in laboratory apparatus design and construction in recent years and also emphasizes how successfully and energetically this old chemical and metallurgical laboratory supply house has kept up with the progress of recent years.

Personal

Mr. D. W. Brunton has returned to Denver from a visit to Greenwood, B. C., where his son, Frederick K. Brunton, is on the smelter staff of the British Columbia Copper Co.

Mr. John V. N. Dorr, of Denver, has returned from an Eastern business and pleasure trip. He attended the Boston meeting of the American Institute of Chemical Engineers and expects to go to Butte for the August meeting of the American Institute of Mining Engineers.

Dr. Rudolf Gahl, of Morenci, Arizona, is on a professional trip in the East.

Mr. H. W. Hardinge, of New York, is in Europe on a business trip.

Mr. Joseph A. Holmes, director of the Bureau of Mines, has taken a party of engineers to Alaska to investigate the Matanuska coal fields.

Mr. Charles W. Newton, general superintendent of the Butte & Ballaklava Copper Company and the Butte & Benith City Mining Company, of Butte, Montana, has gone East on business.

Mr. Benjamin B. Thayer, president of the Anaconda Copper Mining Co., went to Butte in the latter part of July.

Mr. Walter Harvey Weed has purchased the business of the late Horace J. Stevens, of Houghton, Mich., and will edit

and publish the Copper Handbook which, under Mr. Stevens' direction, became an authoritative work on the copper mining companies of the world. Mr. Weed's familiarity with the copper field insures the continuance of an excellent publication.

Mr. H. F. Wierum will have charge of the trial of the Hall process of sulphur recovery at the Balaklava smelter, California.

Superintendent B. L. Wolfe, Profs. E. C. O'Keeffe and A. W. Young accompanied a number of the students from the Kansas School of Mines and Metallurgy to the mining section of southeastern Kansas and southwestern Missouri, in the Joplin district, during the first week in July to give the young men an opportunity of inspecting the actual workings of the mines, smelters and mills of that district.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

REFINING METALS (Continued).

393,526, Nov. 27, 1888, Edward L. Smith, of Ansonia, Conn., administrator of Luther L. Smith, deceased.

Relates to the refining of metals and consists in placing a plurality of sheets of the impure metal in horizontal layers, separated by wood strips and sheets of cotton cloth in an electrolytic cell. The series of plates are so connected electrically that the top plate is the anode and the bottom plate the cathode, the intermediate plates constituting secondary electrodes, the lower side of an upper plate constituting the anode and the upper side of a lower plate, the cathode. During electrolysis any impurities, including gold, etc., collect on the cotton cloth, and may be removed at the end of the operation. The free acid liberated at the cathode being of lower specific gravity than the electrolyte, rises through the cotton cloth and comes in contact with the anode, thus automatically maintaining sufficient circulation.

405,452, June 18, 1889, Charles O. Yale, of Rome, N. Y., assignor of one-half to Moses M. Davis, of same place.

Relates to an apparatus for electrolytically refining base bullion. The impure lead is cast into anodes enclosed in muslin bags and suspended from a radial arm arranged to rotate above a vat. The anodes are arranged in concentric circles. Between the circles of anodes are stationary cylindrical cathodes. To remove the growths from the surface of the cathode a series of combs or scrapers is suspended from one of the radial arms, whereby the surfaces of the cathodes are scraped free from any spongy deposits which then collect at the bottom of the vat. The electrolyte is arranged to be circulated through an independent tank in which it is heated and maintained at a proper density.

405,604, June 18, 1889, Alberto Rovello, of Turin, Italy.

Relates to the precipitation of copper from solutions resulting from the treatment of ores or the so-called "ashes" obtained in roasting copper sulfide in making sulfuric acid. When metallic iron and copper are immersed in such a solution an emf of about 0.60 volt is generated, and if zinc be substituted for the iron the emf increases to about 1 volt. This emf is utilized to generate a current by short-circuiting the electrodes, the current being utilized to deposit copper from the solution. A plurality of the electrodes are assembled in separate compartments of a cell, the several compartments formed by diaphragms; through the compartments containing the copper electrodes is conducted the stream of copper solution, while through the other is conducted a solution containing a similar acid salt of the metal constituting the electrode therein. For the electro-deposition of zinc, solutions of zinc are substituted for the copper solution and the electrodes connected to a dynamo, an emf of not above 1.40 volts being used. The apparatus consists of a plurality of sections of wood, generally U-shaped, separated by diaphragms of porous material and bolted together like a filter press.

Book Reviews

Metallic Alloys: Their Structure and Constitution. By G. H. Gulliver. Second Edition, revised, largely rewritten and greatly enlarged. 12mo, 409 pages, 310 illustrations; price \$3.25 net. London: Chas. Griffin & Co., Ltd.; Philadelphia: J. B. Lippincott Company.

This is a great improvement on the first edition, and as it now stands is perhaps the best elementary presentation in English of the theory of alloy structure. It is not a guide to the practical manufacture of alloys, but to the study of their minute structure and constitution. The author considers alloys as solutions of metals in each other, and applies in detail to them the thermodynamic theory of solutions. Is it accident, or the simple logic of the facts, which excludes the ionization theory of solutions, and even the word "ionization," from the book, although the whole subject is one of solution?

Not as criticism of the book, but as a comment upon the present state of information about alloys, it should be remarked that the book contains no definition of what constitute alloys. True, alloys of iron with carbon are mentioned, also of copper with phosphorus, but where alloys cease and ordinary chemical compounds begin is nowhere explained in the book.

Further, some of the alloys are being spoken of as forming chemical compounds, but the line between solution and chemical compound is drawn very loosely and, as the reviewer thinks, unsatisfactorily; in fact, it is the reviewer's personal opinion that progress in the future will probably lie in the direction of considering *all* solutions as chemical combinations in indefinite proportions, and the definite chemical compounds derived therefrom as being simply particular solutions in definite proportions, individualizing themselves under definite determining conditions.

* * *

Cyanide Practice in Mexico. By Ferdinand McCann. Octavo (15 x 22.5 cm.), 199 pages, 39 illustrations. Price \$2. San Francisco: Mining and Scientific Press. London: The Mining Magazine.

The eighteen chapters cover the cyaniding of gold and silver ores in Mexico, principally silver, and for this reason contain interesting information, because the cyaniding of silver ores has made greater advances in Mexico than in any other part of the world. Lack of a table of contents makes it difficult to summarize, but leafing through the book shows it full of valuable detailed practical information, up to date, expressed in good style, and illustrated by numerous photographs, flow-sheets and working drawings. The large detailed tabulation, by Mr. W. E. Hindry, of complete working details at sixteen plants, arranged under seventy-two columns, is a good and useful piece of work, and deserves special mention.

Most of the book was originally published by the author in the Spanish language.

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Law of Conflicting Uses of Electricity and Electrolysis. By George F. Deiser, Member of the Philadelphia Bar. Octavo (15 x 23 cm.), 138 pages. Price \$2.50. Philadelphia: T. & J. W. Johnson Co.

The legal decisions on these subjects not being numerous as yet, the author has tried to include all that have so far been given, discussing fully those specially concerning electrolysis. The author has only partly carried out his program in that two-thirds of the book relates to the conflicting rights of telegraph, telephone and traction companies to use the streets or highways, and but thirty-eight pages relate to damage by electrolysis.

The latter subject is handled systematically, but most of the material is a recital of the facts and findings in the case of the Peoria Water Works Company *vs.* the Peoria Railway Company, in which corrosion of water mains was caused by the defendant's return current. It may appear a contradictory statement but the definitions of electrolysis and electrolytic

action given in these decisions are so faulty that some one (judge, lawyer, expert or whoever was responsible for them) needed very radical revision of his ideas. If justice was ultimately done in these cases, it was in spite of faulty definitions and not because of correct ones. The general tenor of the decisions, however, that is, as to their ultimate practicability and fairness, appears excellent, and Mr. Deiser has rendered a distinct service to electrochemists in compiling them and thus rendering them accessible.

* * *

American Mine Accounting. By W. H. Charlton. 367 pages, 250 forms and diagrams. Price \$5. New York: McGraw-Hill Publishing Company.

Generally speaking, any technical book of today in order to be one of value, must be a special treatise upon some particular subject.

This book is preeminently one of this type.

One does not have to be an expert accountant in order to appreciate its value to the mining public. Nor is its value restricted in any sense to mining and allied industries, as with slight changes and modifications the forms given therein may be adapted to nearly every line of industry. As scientific management is the path by which many business enterprises have been led from failure or indifferent results and brought to culminate in financial success, a study of the methods employed therein, shows that *detail* is given first consideration. "Small leaks undetected, soon drain the barrel."

Someone has said that 90 per cent of the value of modern education consists in knowing where to find information quickly, and to be able to apply it rapidly and accurately. Therefore to one compiling a system of accounting, where attention to *detail* is so necessary, this book will be found invaluable. Moreover it is thoroughly practical.

This book is also particularly valuable inasmuch as it is an American book and uses terms with which the American mine accountant is familiar. The author refers in his preface to three other books upon the subject; the one published in this country is rather elementary, restricting itself almost entirely to bookkeeping; the other two are English and Scotch books respectively, and hence necessarily contain much which is not readily intelligible on account of the foreign terminology employed.

* * *

Investigations of Methods of Analysis of Cane Products. By William E. Cross, Louisiana Bulletin No. 35 (December, 1912). Agricultural experiment stations of the Louisiana State University and A. & M. College.

This bulletin of 83 pages contains a report of investigations on the methods of analysis of sugar cane products carried out in the Chemical Department of the Louisiana Experiment Station, Audubon Park, New Orleans, La., during the past fifteen months.

"It is universally recognized that accurate chemical control of a sugar factory and dependable analysis of the products turned out are essential to scientific progress in sugar manufacture, and it is therefore a matter of vital importance to have the methods of determination of such products of the highest accuracy and the greatest practicability. In this bulletin are submitted reports of experimental efforts in the direction of elaborating and perfecting such methods, as well as investigations on the analysis of sugar products in general."

The eight chapters of the bulletin deal with the following subjects: The determination of dry substance; the use of the refractometer in sugar-house work. The application of dry lead defecation to sugar-house analysis. A rapid method for the determination of glucose in juices. A modification of the Clerget method of determining sucrose in molasses. The effect of urea and betaine on the rate of inversion of sucrose by hydrochloric acid. The direct determination of sucrose in presence of reducing sugars. The acidity of raw cane sugars. Note on sour cane.

An appendix contains numerous tables. The bulletin on the whole is decidedly interesting and useful.